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THE AMERICAN SOCIETY OF
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The Taxonomic Status and Nomenclature of Some Atlantic and Pacific Populations of Yellowfin and Bluefin Tunas

ISAAC GINSBURG

THE chief object of this paper is to analyze certain taxonomic data that have been previously published by authors regarding some populations of the yellowfin and bluefin tunas, to see what reasonable taxonomic conclusions can be drawn therefrom. Included also are some original data which have been determined on the western Atlantic bluefin tuna.

In taxonomic papers on the family Scombridae, used in a broad sense, the geographic distribution of many species is often stated to be "cosmopolitan." (For recent brief resums of the species of this family, see Fraser-Brunner, 1950, and Rivas, 1951.) However, it should be remembered that such statements, in general, represent the subjective opinion of the author, unsupported by adequate data. This supposition is probably based on the impression that these fishes, being powerful swimmers, roam the seven seas at will. However, in at least one instance where a detailed study of comparable data has been made, namely, the comparison of the populations of bluefin tunas from the American Atlantic and Pacific coasts by Godsil and Holmberg (1950), the cosmopolitan distribution of a single species of bluefin tuna is disproved, as discussed below. It is altogether within the realm of likelihood that other so-called cosmopolitan species will prove to be composites of more than one species, on an objective study of adequate data. Some evidence is here presented which indicates that the two bluefin tuna populations on the opposite Atlantic coasts apparently belong to two distinct species. Also, evidence gleaned from the literature, although inadequate, seems to indicate that the yellowfin tuna populations should also be assigned to more than one species, or at least a number of subspecies should be recognized.

This paper of course is not a definitive finished treatment of the tunas and it is not meant to be taken as such, since extant data are meager and inadequate to solve the various taxonomic problems involved. It is rather meant to present a certain viewpoint to be

taken into consideration in future attempts to solve the problem. In the absence of adequate data we must lean heavily on the known facts of the geographic distribution of fishes in general to draw plausible conclusions. Based on these two factors, our scant knowledge of the taxonomic characters of these fishes taken in conjunction with what we know of zoogeography of fishes in general, the tentative conclusions here arrived at seem to be justified. As the main reliance here is based on zoogeographic rather than morphologic considerations, and because of the necessarily tentative nature of this paper, all Latin names used are binomial, although in some instances the inadequate data would rather indicate that trinomials should more properly be used.

Thunnus thynnus (Linnaeus)

Eastern Atlantic Bluefin Tuna

Scomber thynnus Linnaeus, Syst. Nat., ed. 10 (1): 297, 1758 (inter Tropicos, in Pelago).

This species apparently diverges from the western Atlantic bluefin tuna in a number of characters as discussed under that species. Since Linnaeus did not give a definite locality for his species and his account might apply to more than one species, the name *thynnus* is here formally restricted to the eastern Atlantic population of the bluefin tuna.

Thunnus secundodorsalis (Storer)

Western Atlantic Bluefin Tuna

Thynnus secundo-dorsalis Storer, History of the Fishes of Massachusetts, 1867: 65, pl. 12, fig. 4 (Provincetown, Mass.).

The following specimens of this species were examined in the U. S. National Museum: Woods Hole, Mass. (No. 37928, 625 mm. to tip of tail). Off Cape May, N. J. (93734-5 and 93738-42, 7 specimens 675-775 mm., one partly dissected). Fulton Market, New York City (16509 and 76318, two specimens, skin and head).

The frequency distribution of the number of pectoral rays in these 10 specimens is as

follows: 33 (in 1), 34 (3), 35 (3), 36 (1), 37 (1), 38 (1). For the eastern Atlantic bluefin, Heldt (1931) gave the number of pectoral rays as 30 or 31, and Chabanaud (1930: 149) gave the number of rays as 31 or 32. Frade (1931c: 143) counted the number of pectoral rays in 107 specimens with the following results: 32 (in 27), 33 (63), 34 (17). The combined observations by these three workers on the eastern Atlantic population as compared with the above frequency distribution of the western Atlantic bluefin tuna, indicate that the two populations diverge considerably in the number of pectoral rays, but they also overlap and the precise degree of divergence remains to be determined.

Godsil and Holmberg (1950) published counts of the fin rays and gillrakers of 6 specimens of the Western Atlantic bluefin tuna, and I determined the same counts on 5 other specimens. The combined counts of these 11 specimens are now compared with similar counts made by Frade (1931c) for the eastern Atlantic population, on the coast of southern Portugal.

First dorsal.—Western Atlantic: 13 (in 5), 14 (6). Eastern Atlantic, 104 specimens: 10 (1%), 12 (6%), 13 (60%), 14 (33%).

Second dorsal.—Western Atlantic: attached rays 14 (in 5), 15 (5), 16 (1); finlets 8 (6), 9 (5); combined number of rays and finlets 23 (10), 24 (1). Eastern Atlantic: attached rays 12 (in 3), 13 (41), 14 (67); finlets 8 (1), 9 (72), 10 (38); combined number of rays and finlets 21 (1), 22 (12), 23 (94), 24 (4).

Anal.—Western Atlantic: attached rays 13 (1), 14 (9), 15 (1); finlets 8 (11); combined number of attached rays and finlets 21 (1), 22 (9), 23 (1). Eastern Atlantic: attached rays 12 (4), 13 (79), 14 (19); finlets 7 (1), 8 (41), 9 (60); combined number of rays and finlets 19 (1), 21 (29), 22 (68), 23 (4).

Comparing the above data, the first dorsal averages fewer spines in the eastern Atlantic population, but the degree of divergence is not pronounced. A seemingly higher degree of divergence is shown by the second dorsal and anal counts. In the eastern Atlantic population, the rays average lower and the finlets higher, judged by the data compared, is of subspecies magnitude. However, the indicated differences in the number of second dorsal and anal rays

and finlets might be caused by the method of counting, rather than representing real differences. It is sometimes difficult to decide whether the last partly detached dorsal and anal ray is to be included in the count of the rays or that of the finlets. Frade might have tended to include that ray more often with the finlets, while in the counts of the American specimens it might have been included more often with the rays. When the rays and finlets are included in one count, the differences between the two populations largely disappear.

My studies of the western Atlantic scombrids leads me to consider the further probability that the preceding differences are affected by growth. That is, with growth the last dorsal and anal ray which is partly detached apparently becomes altogether separated from the rest of the fin and turns into a finlet, although the tempo of this change seems to be very slow. As a result large specimens will average fewer rays to some extent and a greater number of finlets. The differences noted above therefore, might be due to the greater average size of Frade's specimens.

The gillrakers of the American specimens vary 12–15 + 25–28, the total count being 39 (in 5), 40 (4), 41 (2). In 147 Portuguese specimens, Frade (1931c: 143) gave the gillraker count as 13 + 24 in 19 specimens and 13 + 26 in 128. His distribution is obviously in error. According to that all 147 specimens had 13 gillrakers on the upper limb and all had either 24 or 26 gillrakers on the lower limb. Those who have had any experience in the determination of intrapopulation variability in fishes in general and scombrids in particular, will know at once that such a distribution is impossible to obtain on an accurate determination, because it just does not occur in nature. Consequently, the gillraker count which, in general, is of much importance in distinguishing scombrid species, still remains to be properly compared as between the two populations concerned. Frade's faulty data perhaps indicate that the eastern Atlantic bluefin averages fewer gillrakers.

Ratios from certain measurements of 8 of the specimens listed above from Woods Hole and Cape May, 574–694 mm. in fork length (distance from end of snout to end of middle caudal rays), are: depth 3.53–4.00, average

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3.68; head 3.19–3.34, average 3.26; pectoral 4.68–5.32, average 4.97, in that length (all measurements taken according to the diagram published by Frade (1931a) for the purpose of comparison). In 6 larger specimens, 1257–1314 mm., from the western Atlantic measured by Godsil and Holmberg (1950: 7), ratios are: depth 3.51–3.96, head 3.40–3.52 and pectoral 4.61–5.08. The body depth and pectoral length of these 6 specimens are nearly the same as in the previous 8 specimens, while the head is proportionally somewhat shorter, which is to be expected because of their larger size. For 100 specimens (1070–2630 mm.) from the eastern Atlantic, Frade (1931a: 119) found the depth 3.85–4.65, average 4.25; head 3.40–3.90, average 3.64; and pectoral 4.85–6.25, average 5.45. The western Atlantic population then has a deeper body and to a lesser extent a longer head and pectoral. The above figures are not strictly comparable as Frade's specimens averaged larger than those from the western Atlantic, while in tunas the measurements of the depth, head and pectoral decrease proportionally in length with increase in size. (These growth changes are discussed at some length by Frade, 1931b, and Heldt, 1927.) However, the differences between the western and eastern Atlantic specimens shown above, especially the difference in the depth, are too pronounced to be wholly accounted for by size.

Measurements given by Heldt (1927) of the Mediterranean bluefin do not differ much from those given by Frade (1931a and 1931b) based on specimens from southern Portugal.

To sum up, the western Atlantic bluefin tuna diverges considerably from that of the eastern Atlantic in averaging fewer pectoral rays and a deeper body. To a lesser extent the head and pectoral also appear to average longer. Possibly the gillrakers are more numerous on the average. In view of these differences and considering that the two populations inhabit different faunal regions, it seems apparent that they should be treated nomenclatorially as distinct. Pending a precise determination of the degree of divergence between them they are here designated by the use of binomials. In any future comparison of the differences between the two populations it is of course important to use the same methods of study

throughout, and measurements and counts must be made with care. It is doubtful whether the data cited above and made by different investigators are rigorously comparable.

Thunnus saliens Jordan and Evermann

American Pacific Bluefin Tuna

Thunnus saliens Jordan and Evermann, 1926: 10, pl. 1 ("Pacific coast of America north to Oregon;" type, a photograph from a specimen taken off Catalina Island, Calif.).

Godsil and Holmberg (1950) showed that the American Pacific bluefin tuna differs specifically from the western Atlantic bluefin. They diverge in the number of gillrakers (p. 11), in the length of the head and preanal distance and other measurements (p. 7), and in some internal characters (p. 39). In general, the degree of divergence between them is evidently of species magnitude, and they should be treated as distinct species, notwithstanding their treatment hitherto as belonging to the same species by most authors.

Although Jordan and Evermann's paper (1926) on the species of tunas is unsatisfactory in that it is based largely on photographs and very little or none of the critical data are included, nevertheless their name *saliens* is the only one that has been proposed for the bluefin tuna from the American Pacific coast. According to the International Rules this name is valid.

Thunnus albacares (Bonnaterre)

Eastern Atlantic Yellowfin Tuna

[*Albacores*, or *Thynni*] Sloane, A voyage to the islands Madera, Barbados, Niever, S. Christophers and Jamaica . . . 1707, vol. 1, p. 11, Tab. 1, fig. 1 (description and figure apparently based on specimen from Madeira; see below).

Scomber albacares Bonnaterre, Tableau encyclopédique et méthodique des trois règnes de la nature . . . Ichthyologie, 1788: 160 (description a translation of Sloane, abbreviated and rearranged; Jamaica only locality given, apparently a lapsus, see discussion below).

Scomber sloanei Cuvier and Valenciennes, Hist. Nat. Poissons, 1831, 8: 148 (based on Sloane's account).

Thynnus albacora Lowe, Proc. Zool. Soc. London, 1839, 7: 77 (Madeira).

Neothunnus argenticittatus Beebe and Tee-Van (in part, see below), 1936: 184 (Sloane's figure republished; eastern and western Atlantic yellowfins treated as one species).

Neothunnus albacora Schaefer and Walford, 1950: 425–43 (yellowfin tunas from Angola and Pacific coast of Costa Rica compared; use of name *argenticittatus* restricted).

The species of yellowfin tunas belonging to the subgenus *Neothunnus* evidently differ specifically in the relative length of the dorsal and anal lobes, at least on the average and in the large specimens. In practice this character is difficult to apply because it changes much with growth and specimens of approximately similar size must be compared. Nevertheless, it seems to be of some value in separating the species. The tunas are not unique in this respect. A similar situation exists in the pompanos, *Trachinotus*, for instance, as discussed below.

A number of authors have noted that in the yellowfin tunas the second dorsal and anal lobes vary markedly in length. These observations have been summarized by Beebe and Tee-Van (1936: 187-88) who quoted from Cunningham (1910: 106), Kishinouye (1923: 446), Frade (1931a: 126), Herre (1936: 106) and Walford (1937: 7). From the remarks made by Kishinouye and by Frade one might infer that two forms or varieties of the yellowfin tuna exist in Japan and the eastern Atlantic, respectively, one with long lobes, the other short-lobed. However, no evidence is produced by these authors to show bimodality in the frequency distribution of these measurements at a given size range, and it is quite likely that their two varieties merely refer to specimens at the two extremes of a regular frequency distribution. Cunningham concludes that it is an age character, the lobes becoming elongated with growth. According to Walford's observations the lobes are "of all lengths, intergrading to such a degree that it was impossible to separate them into two distinct groups." This author also adds significantly that: "In general, the largest, consequently the oldest fish had the longest fins." According to Herre there is "every graduation in the length of the dorsal and anal lobes" and he does not mention any possible relation between the relative length of the lobes and the size of the fish.

The tentative conclusion that may be drawn from a consideration of the sum total of the above observations, is that the lobes become elongated with growth, but at any given size there is a wide range of variation in their length. However, these observations evidently represent merely the general subjective im-

pressions of their respective authors and can hardly form a basis for definite conclusions.

In a brief summary of the family Scombridae, Fraser-Brunner (1950: 144) has the following to say in regard to the question of the length of the lobes in yellowfin tunas: "In some quarters it is still insisted that *T. allisoni* is a distinct Atlantic form characterized by long dorsal and anal fins; such elongation is to be found, however, in all localities where the species reaches full size (note for example the *Neothunnus itosibi* of Jordan and Evermann from Hawaii)." However, no evidence is presented in support of these generalizations regarding the morphology of these fishes. That degrees of differences do exist between the populations of the yellowfin tunas in the length of the dorsal and anal lobes is shown by the evidence discussed hereafter.

An objective study of the variability and growth changes in the length of the dorsal and anal lobes of two populations of yellowfin tunas has been published by Schaefer and Walford (1950). Their study is based on measurements of 60 specimens, 491-1626 mm. long, from Angola made by L. A. Walford, as compared with measurements of 46 specimens, 542-1571 mm. long, from the Pacific coast of Costa Rica made by J. C. Marr and by M. B. Schaefer (see Schaefer, 1948). A similar study was published by Schaefer (1952) comparing measurements of 203 specimens of the yellowfin population from Hawaii with the above specimens from Costa Rica.

The data forming the basis of the two papers cited, that are used by their authors for the purpose of plotting regression lines to show the divergence between the populations, are here reworked and put in a form comparable to that usually employed in taxonomic treatises, and especially one by which the degree of divergence between the populations is more plainly indicated.

Parenthetically it might be added that straight regression lines to show growth changes in the various measurements of fishes should be used with caution. While the study of growth changes in measurements may be said to be still in its infancy, it appears very probable that in most instances such changes are rather curvilinear. The following instances may be cited. Data determined for growth

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changes in the body depth of *Trachinotus carolinus* (Linnaeus) (Ginsburg 1952b: 81) show that the graph representing such changes will form a sharply curved line. Similar data based on a moderate number of specimens referring to species of *Paralichthys* (Ginsburg 1952a: 279-81) suggest that the graph representing the growth change in relative depth quite likely will follow a sinuous course during the life cycle of most species. In *Trachinotus falcatus* (Linnaeus) (Ginsburg 1952b: 72-74), the determined data indicate that the graphs representing growth changes in body depth and the length of the dorsal and anal lobes during the life of the fish will form conspicuously curved lines.

When the data discussed above are divided into size groups (Tables I-II), the number of individuals, in some size groups especially, is rather small. Moreover, for comparative purposes it was necessary to limit the size groups in such manner as to indicate best the divergence between the three populations by the available data, which is not altogether the way the grouping would have been done if the three sets of data were considered independently to determine growth changes only. Nevertheless, in spite of these difficulties, the frame of the data in the tables, at least its skeletal form, leads to the following conclusions: (1) The lobes increase markedly in length with growth, but the rate of increase differs with the population. (2) At every restricted size range the length apparently forms a regular frequency distribution as is usually found in variable data within a given natural population, without showing a definite bimodality. The irregularities in the distributions are readily ascribable to inadequate sampling. (3) The spread of the distribution, in the large size groups especially, is wide. This latter phenomenon is not peculiar to these tunas. It is often found in other species which possess characters that change markedly with growth. The larger size groups especially are apt to include individuals that are markedly either much retarded or much advanced in development with respect to the character that undergoes conspicuous changes with growth. (4) The populations distinctly differ on the average in the length of the lobes, except in the smallest size groups.

While the smaller specimens agree, or nearly

agree, in the relative length of the lobes, it is legitimate to use the difference in the length of the larger specimens in determining the degree of divergence between the populations, as this is evidently an instance in which a species difference does not develop until the adult size is attained. A markedly parallel case is that of *Trachinotus falcatus* as compared with *T. glaucus* (Ginsburg, 1952: 73-74). In the latter two species the relative length of the dorsal and anal lobes is short, and about the same, in the small specimens of both species. With growth, the lobes lengthen markedly, but the rate of increase in length differs with the species and in the large specimens the difference in length becomes a good character in distinguishing the two species.

The differences in the length of the lobes between this population and the other three yellowfin populations here considered are discussed under the accounts of the latter.

Two specimens of the Angola population (here denominated *albacares* and so designated in the tables, for reasons discussed below) fall considerably out of line as compared with the bulk of the specimens (Tables I-II). One specimen in the 751-844 mm. group had the dorsal lobe 24. This specimen very likely is a precocious individual that developed one lobe to a length that is ordinarily attained by larger fish. The other unusual variant, 1468 mm., has the dorsal and anal lobes 36 and 39, respectively, whereas the highest corresponding measurements in all other specimens are 29 and 32. However, the norm of the species is not changed by this one unusual variant out of a sample of 60 specimens. Similar variants occur also in the composite sample from Hawaii.

Beebe and Tee-Van (1936) treated the eastern and western Atlantic yellowfin tunas under one heading and used Cuvier and Valenciennes' name *argenti vittatus* for their composite species. However, that name is not now available for an Atlantic yellowfin tuna. Schaefer and Walford (1950: 441), after corresponding with Dr. Léon Bertin regarding the types of *argenti vittatus*, formally designated a specimen bearing Paris Museum number A5816, from the coast of Malabar, Indian Ocean, as the lectotype. This action once more throws open the question of the proper scientific names to be applied to the Atlantic yellowfin

tunas, that is, assuming that the Atlantic populations are specifically distinct from those of the Pacific and Indian oceans.

In discussing the nomenclature of their Atlantic species, Beebe and Tee-Van concluded that the name *Scomber albacares* Bonnaterre, which was based on a description and figure previously published by Sloane, is not applicable to a yellowfin tuna with certainty because the figure shows a short pectoral. However, Sloane's figure also shows long dorsal and anal lobes, such as apply to the yellowfin tunas only of all the known Atlantic species. After seeing Sloane's published figure, it can hardly be questioned that his specimen actually had notably long lobes. As no species is known that has long dorsal and anal lobes in combination with a short pectoral, it is more than probable that Sloane's figure was drawn from a yellowfin tuna. A damaged fin would be a very plausible explanation to account for the short pectoral as figured. As far as many of the names proposed by early writers are identifiable at all, Bonnaterre's name *albacares* evidently should be used for some species of yellowfin tuna. Taking into consideration what we know now about the structure and geographic distribution of tuna populations, *albacares* is identifiable with greater assurance than many another species established by the early authors.

In order to determine the particular species of yellowfin tuna to which that name is to be applied, it is necessary to determine the type locality of *albacares*. Sloane in his original account, after describing the species, stated as follows:

"It is frequently taken by Sailors with Fisgirs or White Cloath, made like Flying-Fish, and put to a Hook and Line for a Bait; The Flesh is coloured, and Tasts as the *Tunny* of the *Mediterranean*, from whence I am apt to believe it the same fish. It is to be found not only about *Spain*, and in the way to the *West-Indies*; but in the South-Seas about *Guayaquil*, and between *Japan* and *New-Spain* every where."

Sloane then was of the opinion that his fish is world-wide in its distribution. Furthermore, he did not specifically give the locality of the specimen that he described and figured. However, judged by his account in relation to the context of the book—the species is treated in a section devoted entirely to Madeira—

it becomes evident, at least by implication, that the specimen described and figured came from Madeira. The other localities that Sloane mentioned, as cited above, apparently are based on a compilation from the literature, citations to which he included in his account.

Bonnaterre, who formally established the name *albacares*, gave Jamaica as the only locality in his description of the species. However, Bonnaterre's account is not more than a translation of Sloane's description in abbreviated form; and his reference of the species to Jamaica is an evident lapsus that is readily explicable by the fact that the running title in Sloane's book is "*A Voyage to Jamaica*."

On the basis of the evidence then, it seems best to conclude that the type locality of *albacares* is Madeira, a conclusion already reached by Beebe and Tee-Van (1936: 186). Nevertheless, from one point of view Sloane's account, and the name *albacares* on which it was based, might be considered as referring to a composite species, since he ascribed a world-wide distribution to his species. Therefore, it is best to restrict formally the name *albacares* to the yellowfin tuna from Madeira, and it is so restricted herewith.

Thunnus subulatus (Poey)

Western Atlantic Yellowfin Tuna

Orcynus subulatus Poey, 1875, Enumeratio Piscium Cubensium, p. 71 (Cuba).

Thunnus allisoni Mowbray, 1920, COPEIA (78): 9, photo. (Biscayne Bay, Fla.).

Neothunnus argentivittatus Beebe and Tee-Van (not Cuvier and Valenciennes, as restricted by Schaefer and Walford, 1950, and in part; see above), 1936: 184, pls. 3-7, figs. 5-13 (Bermuda; St. Lucia, B. W. I.; description; discussion of nomenclature and synonymy; eastern and western Atlantic yellowfins treated as one species).

Beebe and Tee-Van (1936: 189) measured the percentage length of the second dorsal and anal lobes of 5 specimens of yellowfin tuna from the western Atlantic as follows: Standard length 555 (1), D 11, A 10; 645-690 (2), D 13, A 14; 1360-1450 (2), D 36-38, A 48. Comparing these measurements with those given in Tables I and II, those of the smaller specimens about agree with the measurements of corresponding eastern Atlantic specimens, but the two large western Atlantic specimens have the lobes notably longer, at least on the

average. The length of the dorsal lobe falls out of the range of the bulk of the eastern Atlantic specimens and about agrees with that of the unusual variant discussed above; while that of the anal lobe is markedly greater even than that of the variant. The divergence in the length of the anal lobe would seem to be of species magnitude or nearly so.

The measurements determined by Beebe and Tee-Van and by Schaefer and Walford are comparable, as in both reports the standard length is used as the basis of computation. What Schaefer and Walford call "total length" is defined by Marr and Schaefer (1949: 242) as follows: "The distance from the tip of the snout (most anterior point on upper jaw), with jaws closed, to the cartilaginous median part of the caudal fork (seating the sliding arm of the caliper firmly and thus depressing the small fleshy flap extending posteriorly)." Therefore, "total length" as used by these authors is the same measurement that is generally designated "standard length" by other American authors, including Beebe and Tee-Van.

Measurements of the photograph of the type specimen of *T. allisoni* Mowbray, about 6 feet long, from the coast of Florida are as follows: "fork length" 70.1 mm., dorsal lobe 29 mm., anal lobe 34.3 mm. On a photograph the "fork length," that is, the length from the tip of the snout to the posterior end of the middle caudal rays, is best measured.

In order to compare measurements based on the fork length with those based on the standard length, some correction factor is needed. In scombrids, in general, the fork length is not much greater than the standard length. I have measured 12 specimens, 8 of *T. secundodorsalis* and 2 each of *T. atlanticus* and *Katsuwonus pelamis*, and in these the difference between the fork length and the standard length varies from 3.2 to 4.1 percent of the latter. Accordingly, 3.5 percent in round figures would seem to be a fairly adequate correction factor to convert one length to the other.

According to measurements published by Frade (1929) of one specimen of the eastern Atlantic yellowfin tuna (p. 236) and one specimen of *T. obesus* (p. 230), the correction factor seemingly should be 9 percent. However, the measurement that Frade described as: "Longueur du corps jusqu'au pédoncule

caudal," is apparently less than the standard length of American authors.

Using the above correction factor of 3.5 percent, the photograph of the type of *allisoni* shows the dorsal and anal lobes to be 43 and 51 percent, respectively, of the standard length. While measurements taken from a photograph are often not very reliable, the photograph plainly shows very long lobes and the percentages here determined evidently are near enough for practical purposes.

The three large specimens from the western Atlantic discussed above, the two specimens measured by Beebe and Tee-Van and the photograph of the type of *allisoni* differ widely from 24 large specimens from the eastern Atlantic (the coast of Angola) measured by Walford. However, four other specimens, the extreme variant discussed above and three that entered the literature, altogether two from the eastern and two from the western Atlantic, are rather intermediate. One specimen from Bermuda, 1220 mm. in total length, figured by Beebe and Tee-Van (1936, pl. 4), has the dorsal and anal lobes 22 and 24 percent, respectively, also determined by measuring the photograph and calculating on the basis of the above correction factor. These measurements fall in the distribution of the group 1166–1381 mm. in standard length from Angola (Tables I–II). A much larger specimen from Maryland, 192 pounds, figured by Nichols and LaMonte (1941: 29), has the dorsal and anal lobes 27 and 37 percent, respectively, calculated the same way as the preceding specimen. The measurement of the dorsal lobe of the Maryland specimen falls within the range of the large Angola specimens, while that of the anal lobe nearly agrees with the extreme Angola variant. In contrast with the preceding two western Atlantic specimens are the following two eastern Atlantic specimens. One, the extreme variant from Angola which has the dorsal and anal lobes 36 and 39, respectively, and another specimen, 1700 mm. fork length, the measurements of which are given by Frade (1929: 236), has the dorsal and anal lobes nearly of the same length, 34 and 37, respectively. The dorsal and anal lobes of the latter two specimens are moderately higher than those of 24 similar-sized specimens from Angola (given in the tables), and closely approach the preceding

western Atlantic specimen. It should be noted, however, that the comparison is not altogether fair as the measurements of the two western Atlantic specimens are based on photographs.

On the whole, considering the extant evidence from the western Atlantic, it may be reasonably concluded that large specimens of the western Atlantic yellowfin tuna have the dorsal and anal lobes considerably longer, at least on the average, than similar specimens from the eastern Atlantic. While the existing evidence is meager, nevertheless it shows that this population as compared with that from the eastern Atlantic, is entitled to separate nomenclatorial recognition; but the evidence is not of sufficient extent to make a final decision regarding the taxonomic category in which it is to be placed. To simplify matters a binomial is here used to designate this population, pending an adequate determination of its extent of divergence.

According to Poey the dorsal and anal lobes of his *subulatus* were much longer than the pectoral. It is evident, therefore, that Poey described a yellowfin tuna and his name *subulatus* takes precedence over *allisoni* of Mowbray.

Thunnus catalinae (Jordan and Evermann)

American Pacific Yellowfin Tuna

Neothunnus catalinae Jordan and Evermann, 1926: 19, pl. 4 (Santa Barbara Islands, Calif.; type, No. 597, Mus. Calif. Acad. Sci., a photograph of a fish taken off Catalina Island, Calif.).

An inspection of the data in Tables I and II shows that the eastern Pacific population diverges considerably from those of the western Pacific and eastern Atlantic in having shorter dorsal and anal lobes, in large specimens, but the data are insufficient to determine satisfactorily the precise degree of divergence. Nevertheless, it may be reasonably expected that adequate data will show that this population properly should be recognized nomenclatorially, especially as compared with the western Pacific population. Since this population already received formally a separate designation, it is best to continue this course. Pending the determination of adequate data, a binomial is here tentatively used to designate this population.

The name *catalinae*, which is nomenclatorially valid, is the only one proposed for the yellowfin tuna of the American Pacific coast and should be applied to this population although its original account is unsatisfactory.

Thunnus macropterus (Temminck and Schlegel)

Western Pacific Yellowfin Tuna

Thynnus macropterus Temminck and Schlegel, 1842, Fauna Japonica, p. 98, pl. 51 (Japan).

While the eastern Pacific yellowfin tuna apparently is nearest to that of the eastern Atlantic in the length of the dorsal and anal lobes, that of the western Pacific, including Oceania, seems to be nearest to the one in the western Atlantic in these measurements—both having comparatively long lobes in the larger specimens. Kishinouye (1923: 446) stated in his description of the Japanese population: "The second dorsal and the anal are much elongated, especially in the variety named *itoshibi* or *gesunaga*, the tips of these fins are whitish and reach to the base of the caudal." Jordan and Evermann (1926: 83) published a photograph of a large specimen from Hawaii with very long lobes (which they described as a new species, *itosibi*). Fowler (1933: 164) described and figured a large specimen from Tahiti with very long lobes (which he established as a new genus and species, *Semathunnus guildi*). Nichols and LaMonte (1941: 29) likewise published a photograph of two large specimens from Hawaii with very long fins. The data published by Godsil and Byers (1941: 48-49) would also seem to indicate that the western Pacific yellowfin has longer lobes as compared with that from the eastern Pacific. Their specimens were not large comparatively and their data are not well comparable in regard to the size of the fish. Their samples from Perú and Japan comprised the largest specimens, and although not altogether comparable as to size, those from Japan have distinctly longer lobes.

Judged strictly by the data in Tables I-II, the western Pacific yellowfin population diverges from that of the eastern Atlantic to a degree that is only of racial magnitude and is not entitled to separate nomenclatorial standing. However there are other factors to be considered: (1) Specimens of the two populations have not been directly compared as

TABLE I

FREQUENCY DISTRIBUTION OF THE LENGTH OF THE SECOND DORSAL LOBE EXPRESSED AS A PERCENTAGE OF THE STANDARD LENGTH, SEGREGATED BY SIZE GROUPS, OF *Thunnus albacares* FROM ANGOLA, *T. catalinae* FROM THE PACIFIC COAST OF COSTA RICA, AND *T. macropterus* FROM HAWAII
From the data published by Schaeffer (1948 and 1952) and Schaeffer and Walford (1959).

Species	Standard length, mm.	Length of second dorsal lobe												
		9-11	12-14	15-17	18-20	21-23	24-26	27-29	30-32	33-35	36-38	39-41	42-44	45-46
<i>albacares</i>	491	1	..	..	..	..	..	..	..	..	..	..	..	..
<i>catalinae</i>	542-662	5	2	..	..	..	..	..	..	..	..	..	..	..
<i>macropterus</i>	451-656	9	21	..	..	..	..	..	..	..	..	..	..	..
<i>albacares</i>	751-844	..	5	16	..	..	1	..	..	..	..	..	..	..
<i>catalinae</i>	693-897	..	8	3	..	..	..	..	..	..	..	..	..	..
<i>macropterus</i>	681-888	..	2	3	2	..	..	..	..	..	..	..	..	..
<i>albacares</i>	985-1133	..	..	1	2	..	..	..	..	..	..	..	..	..
<i>catalinae</i>	918-1132	..	5	11	2	..	..	..	..	..	..	..	..	..
<i>macropterus</i>	912-1134	..	..	9	16	1	..	..	..	..	..	..	..	..
<i>albacares</i>	1166-1381	..	..	..	5	10	6	2	..	..	..	..	..	..
<i>catalinae</i>	1144-1242	..	..	1	3	2	..	..	..	..	..	..	..	..
<i>macropterus</i>	1142-1399	..	..	1	2	17	13	15	2	..	..	..	..	..
<i>albacares</i>	1406-1626	..	..	..	..	2	3	4	..	..	1	..	..	..
<i>catalinae</i>	1411-1571	..	..	1	1	1	..	..	..	..	..	..	..	..
<i>macropterus</i>	1405-1621	..	..	..	..	4	5	10	9	8	3	3	..	..
<i>macropterus</i>	1629-1785	..	..	..	..	..	1	1	2	13	14	11	2	1

TABLE II

FREQUENCY DISTRIBUTION OF THE LENGTH OF THE ANAL LOBE IN THREE SPECIES OF *Thunnus*
Calculated as in Table I and from the same sets of data

Species	Standard length, mm.	Length of anal lobe														
		8-10	11-13	14-16	17-19	20-22	23-25	26-28	29-31	32-34	35-37	38-40	41-43	44-46	47-49	50-52
<i>albacares</i>	491	1	..	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>catalinae</i>	542-662	..	7	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>macropterus</i>	451-656	8	23	..	..	..	..	..	..	..	..	..	..	..	..	..
<i>albacares</i>	751-844	..	..	20	2	..	..	..	..	..	..	..	..	..	..	..
<i>catalinae</i>	698-897	..	4	5	1	..	..	..	..	..	..	..	..	..	..	..
<i>macropterus</i>	681-888	..	..	4	1	2	..	..	..	..	..	..	..	..	..	..
<i>albacares</i>	985-1133	..	..	1	1	1	..	..	..	..	..	..	..	..	..	..
<i>catalinae</i>	918-1132	..	..	6	9	3	..	..	..	..	..	..	..	..	..	..
<i>macropterus</i>	912-1134	..	..	3	9	11	2	..	1	..	..	..	..	..	..	..
<i>albacares</i>	1166-1381	..	..	..	1	6	10	4	3	..	..	..	..	..	..	..
<i>catalinae</i>	1144-1242	..	..	..	1	4	1	..	..	..	..	..	..	..	..	..
<i>macropterus</i>	1142-1399	..	..	..	1	4	14	14	13	3	1	..	..	..	..	..
<i>albacares</i>	1406-1626	..	..	..	1	..	1	3	2	2	..	1	..	..	..	..
<i>catalinae</i>	1411-1571	..	..	..	..	2	..	1	..	..	..	..	..	..	..	..
<i>macropterus</i>	1405-1621	..	..	..	..	..	4	1	7	7	11	5	5	1	..	1
<i>macropterus</i>	1629-1785	..	..	..	..	..	..	..	3	2	11	6	13	7	2	1

yet. (2) Not all promising phases of the morphology of these two populations have been studied and compared. (3) They inhabit totally different faunal areas. Very few species are now considered to be common to both areas, and the adequacy of the treatment of even these few supposedly common species has not been firmly established as yet. Consequently, it is very probable that the two tuna populations concerned will eventually be found to belong to two distinct species. (4) Most authors have treated them as distinct species.

In view of these other factors and to avoid the possible confusion that might be caused by shifting names in and out of the synonymy, it seems best to continue to treat the two populations tentatively under separate binomial headings, as they have been treated generally heretofore, until adequate data are furnished to determine the question one way or the other. Likewise, the precise differences between the western Pacific and western Atlantic populations still remain to be determined.

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Revision and Systematic Position of the Blennioid Fishes of the Genus *Neoclinus*

CLARK HUBBS

THE FISHES of the genus *Neoclinus* were revised by me in connection with my studies on the clinid fishes of the eastern Pacific before it was realized that these fishes are not clinids. It now appears that *Neoclinus* is referable to the Blenniidae and, more specifically, to the subfamily Chaenopsinae, within which it may be regarded as constituting one of four tribes (Hubbs, 1952). This concept involves a regrouping of genera which previous authors have placed in several families.

For permission to examine specimens, the author is indebted to George S. Myers and Margaret H. Storey, of Stanford University; Wilbert M. Chapman and W. I. Follett, of the California Academy of Sciences; Carl L. Hubbs and Boyd W. Walker, of the University of California; John S. Garth, of the University of Southern California; and Robert R. Miller, formerly of the United States National Museum. Thanks are due to Norman J. Wilmovsky for help in the work on *Stathmonotus* and for helpful discussions on other aspects of the problem. George S. Myers, Carl L. Hubbs, Rolf L. Bolin, and Catherine S. Hubbs have read and criticized drafts of the work. Figure 12 was drawn by Alma W. Froderstrom; the remaining drawings were made by Grace Hewitt, from sketches by the author.

With one exception, the methods of counting and measuring used in this investigation have been those described by Hubbs and Lagler (1941). The spine lengths were measured from the posterior base of the spine. In the discussions of meristic characters the extreme variation is listed first, followed by the usual range (or number) in parentheses.

A modification of the graphic method proposed by Dice and Leraas (1936), and supplemented by Hubbs and Perlmutter (1942), is used; it was developed jointly with Carl L. Hubbs. In each bar the base line represents the extreme range, the vertical line represents the mean, the solid area represents two standard errors on each side of the mean, and the outlined area represents one standard deviation on each side of the mean.

The group-name endings which are used are those recommended by the American Society of Ichthyologists and Herpetologists (COPELA, 1950: 326).

The following abbreviations are used for collections in which the specimens are deposited: SU, Stanford Natural History Museum; CAS, California Academy of Sciences; USNM, United States National Museum; UMMZ, University of Michigan Museum of Zoology; UCLA, University of California at Los Angeles; USC, University of Southern California; NYZS, New York Zoological Society; RUC, Rhodes University College; and TNHC, Texas Natural History Collection.

FAMILY BLENIIDAE

The generally accepted limits of the family Blenniidae were outlined by Regan (1912). The blenniids were divided by Norman (1943) into 3 subfamilies—Ophioblenniinae, Blenniinae, and Salariae—and he placed most of the nominal genera and species into these groups. Chapman (1951) has shown that *Ophioblennius* and its relatives represent larval stages of *Cirripectus* and its relatives. Regan placed *Neoclinus*, *Emblemaria*, and related genera in the Clinidae. The author (Hubbs, 1952) believes that these genera should be removed from the Clinidae and placed in the Blenniidae, to comprise the subfamily Chaenopsinae, which also includes *Stathmonotus* and *Chaenopsis*. All blenniids have high, anterior eyes and stout suborbitals, and the first suborbital is extended posteriorly to bound the anterior half or more of the eye ventrally. In the clinids, in contrast, the eyes are normally located, the suborbitals are weak, and the first suborbital is not extended to the middle of the eye. The members of the Chaenopsinae, as thus constituted, further resemble the Blenniidae in having few, incisor-like, recurved teeth and no scales (or, in *Neoclinus*, very minute ones).

The origin and dissemination of the family Blenniidae is obscured by the lack of fossil evidence. On the basis of geographical distribution and comparative anatomy, however, Hubbs

(1952) suggested that the family split off from the main stem of the superfamily Blenniidae in the warm seas of the Americas. It was further proposed that the Chaenopsinae represents an early New World offshoot of the Blenniidae. The stem species of the typical Blenniidae then presumably migrated to the Indo-Pacific and divided there (if not in the New World) into the Blenniinae and Salariinae. The phylogeny of the Salariinae has been studied by Chapman (1951) and will not be discussed further here. It may be assumed that the subfamily Blenniinae then dichotomized in the Indo-Pacific to form the tribes Blenniidi and Petrosirritidi. The fishes of these two groups and of the Salariinae eventually spread over most of the tropical seas.

It was further assumed that when the stem species of the typical blenniids migrated to the Indo-Pacific, the Chaenopsinae remained in the Americas. The first group to diverge from the subfamily stalk seemingly was the Neoclinidi, for the retention of scales, lateral line, and conical teeth stamp this as the most primitive living blennioid group. This tribe either originated in or migrated to the coasts of California, from where *Neoclinus bryope* (Jordan and Snyder) presumably emigrated to Japan through the Aleutians during an Interglacial period. The remaining members of the subfamily remained in tropical waters on both sides of Central America. It seems probable that the next group to differentiate was the Stathmonotidi. Shortly thereafter the more closely related Emblemariidi and Chaenopsidi were separated.

SUBFAMILY CHAENOPSINAE Gill

This subfamily is composed of a number of genera of "blennioid" fishes which have been scattered among several families. They can be distinguished from all other members of the Blenniidae by the posterior extension of the first suborbital so that it bounds the entire ventral border of the eye. Unlike most members of the Blenniidae, all of the species have some conical teeth in the jaws, and a few of the teeth may be slightly enlarged and recurved. Those of the anterior portion of the jaws are often somewhat incisor-like but none is ever comb-shaped. The upper jaw typically

extends well beyond the eye. The body is usually anguilliform.

Four tribes (the Neoclinidi, Stathmonotidi, Emblemariidi, and Chaenopsidi) are here recognized in this subfamily. All except the Neoclinidi occur in the tropical American marine waters of the Caribbean and Pacific. The Neoclinidi live on both sides of the temperate north Pacific.

KEY TO THE TRIBES OF THE CHAENOPSINAE

- 1a. Body scaled; lateral line present. Neoclinidi
- 1b. Body naked; no lateral line pores on body.
 - 2a. No soft rays in dorsal; supraorbital cirri oval and entire. Stathmonotidi
 - 2b. More than 10 soft rays in dorsal; supraorbital cirri, if present, elongate and usually deeply cleft.
 - 3a. More dorsal spines than soft rays; head blunt; supraorbital cirri usually present. Emblemariidi
 - 3b. More dorsal soft rays than spines; head sharply pointed; supraorbital cirri absent. Chaenopsidi

TRIBE NEOCLINIDI

This small tribe is found in rocky crevices from near the low-tide line to thirty-three fathoms along the temperate coast of the north Pacific. I recognize only one genus in the tribe.

Neoclinus Girard

Neoclinus Girard, 1858: 114 (type species by monotypy *N. blanchardi* Girard).

Pterognathus Girard, 1859: 57 (name mentioned as possible generic name for *N. satiricus* Girard = *N. blanchardi* Girard).

Zacalles Jordan and Snyder, 1903: 448 (nec *Zacalles* Foerster, 1868, an insect; type species by original designation *Z. bryope* Jordan and Snyder).

Calliblenius Barbour, 1912: 187 (substitute for *Zacalles* Jordan and Snyder; same type).

DESCRIPTION.—Dorsal XXIII to XXVII, 14 to 18; anal II, 26 to 31; total dorsal and anal rays 68 to 76; caudal 11; pectorals 12 to 16; pelvics I, 3; branchiostegal rays 6 to 7 (6); anterior lateral-line scales 17 to 27; scale rows from posterior end of anterior lateral-line scales to caudal base 65 to 105; gill rakers 4 to 10 + 8 to 14 = 12 to 22.

The head and snout are blunt. The jaws are terminal, but below the midline. The width of the slightly projecting lips vary from 0.67 to

2.5 times that of the suborbital. The posterior limit of the upper jaw ranges from a point below the occiput to a point behind the head. The eye is anterior and dorsal. The posterior edge of the preopercle is two-thirds of the distance back on the bony postorbital length. The cirri in this genus are variable, but are always present over the anterior nostril and over the orbit; the orbital cirri are the most prominent.

There are conical teeth on the premaxillaries, mandibles, vomer, and palatines. Those on the jaws comprise a row of larger teeth enclosing a mesial band of smaller teeth (more on the upper jaw than on the lower). The vomer and palatines have only the larger teeth. The larger teeth in the anterior part of the jaws often are somewhat incisor-like.

The straight to convex profile ascends steeply to the eye, from which it rises very gently to the vicinity of the first dorsal spine. The profile either drops gently along the dorsal base or is level along the spinous dorsal and drops along the soft dorsal. The caudal peduncle is short and deep. The body is rounded.

The dorsal originates above a point between the eye and posterior margin of the preopercle. The anterior spines are soft and flexible, and there is a tendency for the posterior spines to be stiffer. The dorsal outline is smooth. There is a slight rise from the first to fourth spines, then a gradual decline over the posterior end of the spinous dorsal. The last spine may or may not be noticeably shorter than the next to last spine. The soft rays are longer than the posterior spines and may or may not be longer than the anterior spines. The soft dorsal has a level margin, except along the last two rays, which are slightly shortened. The tips of the last rays extend considerably beyond the base of the caudal and the last ray is attached to the caudal peduncle by a membrane. The spines and rays are equally spaced, except the most anterior, which are slightly farther apart than the others. The membranes are slightly incised (increasingly so anteriorly). The spines do not bear flags. The short and rounded caudal has no divided rays.

The two anal spines are short, flexible, and closely approximated. The first soft ray is normally twice as long as the first spine. The remaining soft rays are each slightly longer than the preceding ray, except for the last two

which are slightly shorter. The tips of the last rays extend considerably beyond the caudal base, but the last ray is not attached to the caudal peduncle by a membrane. The membranes are incised from one-third to one-fourth the length of the adjacent ray.

The ninth to eleventh ray of the short and rounded pectorals is the longest. The membranes are slightly incised. The lower rays are thicker than the upper. The second soft ray of the short pelvics is the longest.

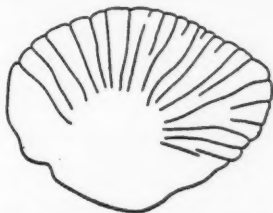


Fig. 1. Body scale of *Neoclinus blanchardi*.

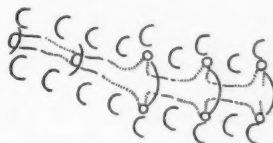


Fig. 2. Anterior lateral-line scales of *Neoclinus blanchardi*.



Fig. 3. Posterior lateral-line scales of *Neoclinus blanchardi*.

The small, imbedded and nonimbricate scales have no radii on their posterior margins (Fig. 1). There is a scaleless area on the belly and another along the anterior part of the dorsal. The head and all fins, except the extreme base of the caudal fin, are naked.

The lateral line runs posteriorly from the upper margin of the opercle on 18 to 25 scales. Some additional pores may or may not be present on the mid-line posteriorly. Scales on the anterior portion normally have a pore

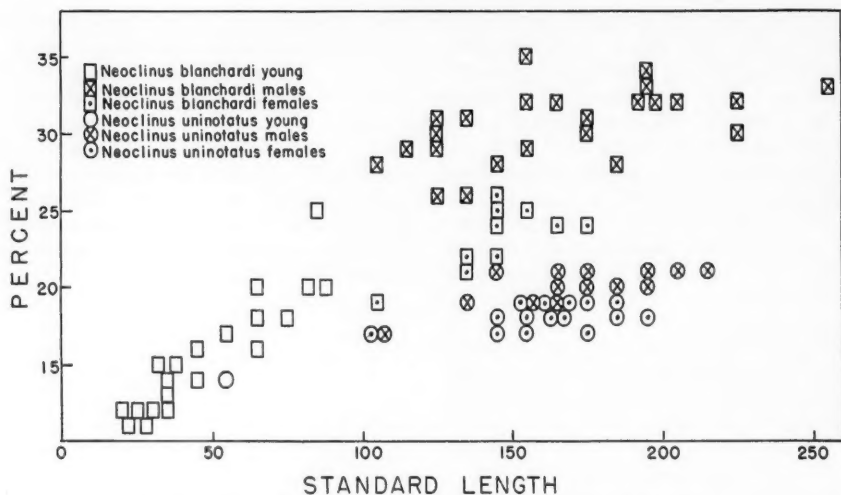


Fig. 4. Standard length into upper-jaw length in two species of *Neoclinus*.

above and below the canal (Fig. 2). Posterior lateral-line scales have a single minute central pore (Fig. 3). There is a double or triple row of pores on the mandibular and infraorbital lateral-line canals.

The members of this genus are believed to live in crevices in the rocks below low-tide level. According to Fitch (1949) *N. satiricus* (= *N. blanchardi*) lives in rock holes with only its head exposed. Vernon E. Brock (personal communication, 1950) reports that a "new blenny" he observed off Santa Catalina Island has similar habits. His description seems to fit *N. stephensae*.

Neoclinus comprises four species: *stephensae*, new; *uninotatus*, new; *blanchardi* Girard; and *bryope* (Jordan and Snyder). The species here named *uninotatus* has long passed under the name *N. blanchardi*, but an examination of the type specimens and type descriptions shows that the name *blanchardi* belongs to the species later named *N. satiricus*. The four species can be distinguished by Table I and the following key:

KEY TO THE SPECIES OF *Neoclinus*

- 1a. Total gill rakers more than 15; all orbital cirri of about equal size; adults always less than 100 mm. standard length.
- 2a. No ocellus on dorsal fin; a cirrus on nape; total pectoral rays (both fins) usually 30 (Fig. 5).....*stephensae*
- 2b. One ocellus on membrane between first two dorsal spines; no cirrus on nape; total pectoral rays usually 28 (Fig. 5).....*bryope*
- 1b. Total gill rakers fewer than 15; anterior orbital cirrus in males much enlarged; adults always more than 100 mm. standard length.
- 3a. One ocellus on dorsal fin, none on the membrane between sixth and ninth dorsal spines; supraorbital cirri large, more than one longer than half eye diameter; upper jaw moderate, in adult males less than one-fourth standard length (Fig. 4); eye smaller, usually less than 6.0 in standard length (Fig. 6).....*uninotatus*
- 3b. Two ocelli on dorsal fin, one on membrane between sixth and ninth dorsal spines (not present in post-larvae); supraorbital cirri short, only one more than half eye diameter; upper jaw large, in adult males more than one-fourth standard length (Fig. 4); eye larger, usually more than 6.0 in standard length (Fig. 6).....*blanchardi*

SEXUAL DIMORPHISM.—The species of *Neoclinus* show considerable secondary sexual dimorphism. Since only a few adult specimens of *N. bryope* and *N. stephensae* have been examined, the discussion of sexual differences will be confined to *N. blanchardi* and *N. uninotatus*. There is a strong indication, however, that

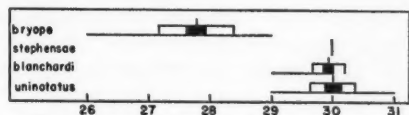


Fig. 5. Total number of pectoral rays, both fins, in *Neoclinus*.

distance from the anal origin to the pelvic insertion is greater in females than in males (Fig. 7), and is of statistical significance in both species. The body depth at the anus is statistically greater in males than in females in both species (Fig. 8). The first anal soft ray is longer in males than in females (Fig. 9), and is of statistical significance in both *N. blanchardi* and *N. uninotatus*. The fifth dorsal soft ray is longer in males than in females (Fig. 10), and is of statistical significance in *N. uninotatus* and of marginal significance in *N. blanchardi*. The distance from the snout to the dorsal is greater in males than in females (Fig. 11), and

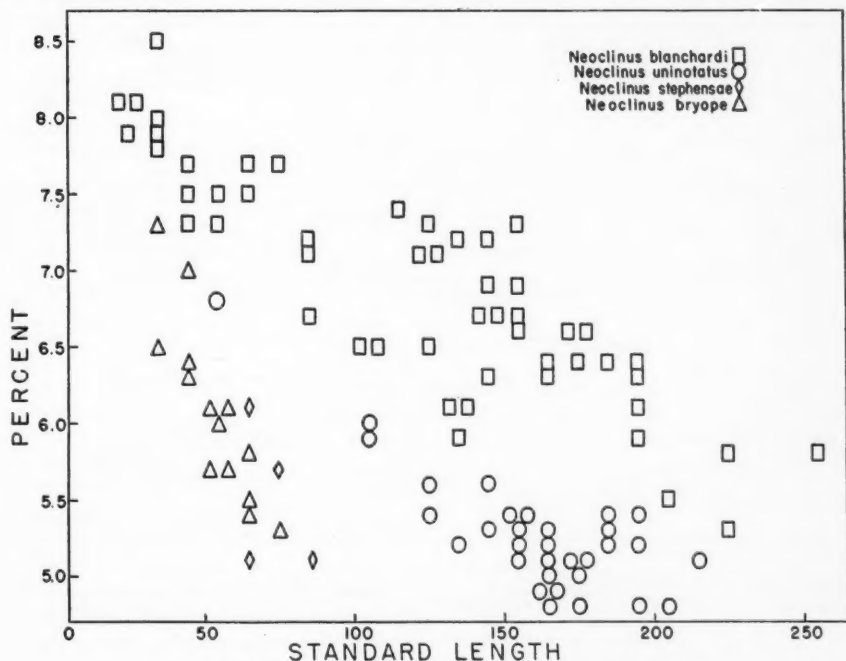


Fig. 6. Standard length into eye length in four species of *Neoclinus*.

the two smaller species have similar differences. The description of the sexes of *Neoclinus blanchardi* as different species by Girard (he suggested that they might even be generically separable) illustrates how marked this sexual differentiation may be.

The dimorphism of the upper jaw length (Fig. 4) is perhaps the most pronounced. The

is of statistical significance in *N. blanchardi* and of marginal significance in *N. uninotatus*.

Neoclinus stephensae, sp. nov.

Figure 12

The holotype, 69 mm. SU No. 16331, was dredged from 10 fathoms off the east coast of South Coronado Island, Baja California, on

August 11, 1948, by Carl L. Hubbs and party on the Schooner E. W. SCRIPPS. Three para-

TABLE I

COMPARISON OF PROPORTIONAL MEASUREMENTS OF THE SPECIES OF *Neoclinus*

The measurements are expressed as hundredths of the standard length.

Measurement	Species			
	uninotatus	blanchardi	steph- ensae	bryope
Head length.....	24-29	27-34	22-24	23-28
Snout length.....	5-7	5-8	4-5	4-6
Eye to preopercle (in line with bony postorbital length).....	8-12	7-14	9	8-9
Snout to dorsal.....	17-19	18-22	16	15-20
Nape to maxillary.....	13-16	15-19	14	12-14
Interorbital (fish above 100 mm.).....	1.6-2.2	2.3-4.3	—	—
First dorsal spine length.....	7-9	9-14	9-10	7-12
Fourth dorsal spine length.....	8-11	10-15	9	9-15
Soft dorsal base length.....	23-28	23-30	27-29	26-31
Anal origin to pelvic insertion.....	22-32	23-33	19-24	21-27
Longest pelvic ray length.....	11-14	13-19	11	10-15
Longest pectoral ray length.....	14-16	15-21	13	12-17
Body depth.....	14-17	13-17	14-15	12-15
Width at junction of mandibular lateral line.....	8-10	7-12	8-9	7-9

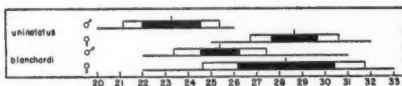


Fig. 7. Sexual dimorphism in *Neoclinus*: standard length into the distance from the anal base to the pelvic base, in percents.

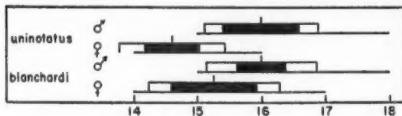


Fig. 8. Sexual dimorphism in *Neoclinus*: standard length into body depth, in percents.

types: SU No. 22518, collected from a tide pool on Point Loma, California, by Mrs. Kate

Stephens; USNM No. 160617, collected from 10 feet at the entrance to Newport Bay, California, by Conrad Limbaugh; and TNHC No. 2007, taken from 18 feet in Newport Bay off Balboa, California, by Conrad Limbaugh. (Since this paper went to press, one specimen was collected from Hassler Cove, San Martín Island, Baja California. Its characters agree with the species description, with the following exceptions: the gill rakers number $6 + 12 = 18$, and there is a faint spot between the first two dorsal spines.)



Fig. 9. Sexual dimorphism in *Neoclinus*: standard length into first anal soft-ray length, in percents.

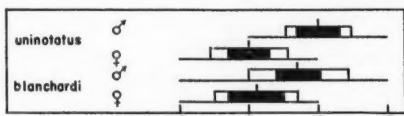


Fig. 10. Sexual dimorphism in *Neoclinus*: standard length into fifth dorsal soft-ray length, in percents.

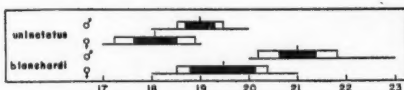


Fig. 11. Sexual dimorphism in *Neoclinus*: standard length into predorsal length, in percents.

Dorsal XXV to XXVII, 15 to 17; anal II, 29 to 30; total dorsal and anal rays 72 to 74; pectoral 15; anterior lateral line scales 19 to 20; gill rakers 6 to 8 + 13 to 14 = 19 to 22.

The width of the lips equals that of the suborbital. The maxillary extends to a point below the nuchal cirrus. The narrow interorbital is V-shaped. The cirri are very prominent: one on the nape, four over the orbit, and three on the anterior nostril. All except the nuchal are much branched. Two or three over the orbit are longer than the eye, but none is greatly produced.

The convex profile rises steeply to the nape; there is a slight rise from the nape to the first

dorsal spine, at which point the profile drops evenly and gently to the caudal fin.

The dorsal fin originates about halfway between the posterior margins of the opercle and of the eye. The anterior dorsal spines are soft and flexible, gradually becoming stiff toward the posterior end; the last third are sharp and not flexible. The soft dorsal rays are slightly longer than the longest spines. The last dorsal ray for half of its length is attached by a membrane to the caudal peduncle (as far as the most anterior procurent caudal rays). The first anal soft-ray is twice the length of the first spine. The tenth ray of the short and rounded pectorals is the longest. The first pelvic soft-ray is the shortest. The membrane between the first and second rays is deeply incised and that between the second and third is slightly incised.

with very thick bluish speckling on the lower parts. There is a dark spot on the opercular membrane. The eye is dull reddish.

This rare species has a very limited recorded range, from Newport Bay, California, to South Coronado Island, Baja California. It occurs in rocky areas from the low-tide level to a depth of ten fathoms. If Brock's "new blenny" (see discussion under genus) belongs to this species, the range should be extended to include Santa Catalina Island, California.

As all four specimens examined are males, no sexual dimorphism was noted, but the characters are those to be expected in males. The specimens are all mature and between 60 and 82 millimeters in standard length.

The differences between *N. stephensae* and the other two California species are obvious, whether young or adult specimens of the larger

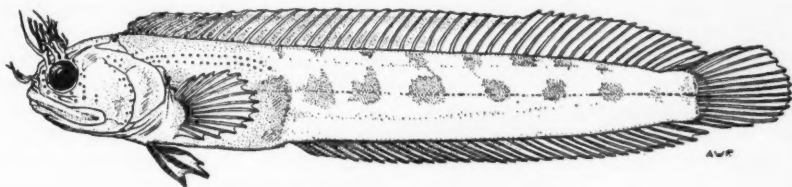


Fig. 12. Holotype of *Neoclinus stephensae*.

The body is scaled behind a line which runs from the anus anteriorly to the pectoral base and then along the opercle to the lateral line. Above the lateral line there are no scales as far posterior as the end of the double pores; then the naked band grows progressively narrower to the anterior end of the soft dorsal, where it disappears. The lateral line runs straight from the upper margin of the opercle for 18 scales with paired external pores, followed by a scale with a single median pore. The few single pores on the midline posteriorly are tiny and very difficult to see.

The following color description is based on the holotype only. The body has 12 interrupted purplish bars. There are bright blue spots on the belly and some bluish reticulations on the sides above. The dorsal fin has deep red dashes on the spines and greenish specks on the membranes. The anterior part of the fin has a light cream border and no ocellus. The caudal fin and the posterior part of the dorsal and anal fins are bright yellow. The head is dusky purplish,

species are compared with the small adult males of *stephensae*.

Named *stephensae* in honor of the malacologist, Mrs. Kate Stephens, now over 100 years old, who first collected the fish.

Neoclinus bryope (Jordan and Snyder)

Zacalles bryope Jordan and Snyder, 1903: 448; Snyder, 1912: 447-8 (*Zacalles* misspelled); Jordan, Tanaka, and Snyder, 1913: 380; Okada and Matsubara, 1938: 395; Okada, 1938: 258. *Calliblennius bryope* Barbour, 1912: 187. *Neoclinus bryope* Hubbs, 1952: 52.

This species, formerly treated as the type of a distinct genus, *Calliblennius*, is referable to the California genus *Neoclinus*. It is probably most closely related to *N. stephensae* but is readily separable from that species by the presence of an ocellus on the membrane between the first two dorsal spines, by the absence of a nuchal cirrus, and by usually having 14 instead of 15 pectoral rays. Specimens of both *stephensae* and *bryope* can be separated from *blanchardi* and *uninotatus* by the smaller size at maturity

(under 100 millimeters standard length as opposed to over 100 millimeters standard length), by the more numerous gill rakers (about 20 instead of about 12), and by the smaller size of the eye (Fig. 6).

The holotype, SU No. 7067, and many paratypes, SU Nos. 7102 and 21171, which were collected by Jordan and Snyder at Misaki, Japan, were examined.

Dorsal XXIV to XXVI (XXV to XXVI), 14 to 18 (16 to 17); anal II, 28 to 31 (29 to 30); total dorsal and anal rays 70 to 76 (72 to 75); pectorals 12 to 15 (14); anterior lateral line scales 19 to 23 (20 to 23); gill rakers 10 + 10 = 20.

The width of the moderate lips is contained 0.8 times in that of the suborbital. The upper jaw extends to a point below the occiput. The narrow interorbital is concave. The cirri are relatively few: none on the nape, three over the eye, and two to four on the anterior nostril. They are all very much branched and from 0.5 to one eye diameter in length.

The slightly convex profile rises steeply as far as the anterior margin of the eye, from which it rises very gently until about the fifth spine, where it gently drops to the base of the caudal fin.

All of the dorsal spines are thin and flexible except the last, which is stiff. Usually the last spine is noticeably shorter than the others, but the membrane is not incised; *i. e.*, the last spine does not reach the edge of the membrane. The soft dorsal is slightly higher than the highest rays of the spinous dorsal. The last dorsal ray is attached only at its base to the caudal peduncle by a membrane. The first anal soft ray is approximately twice the length of the first spine. The tenth ray of the short and rounded pectorals is the longest. The third pelvic soft ray is the shortest. The pelvic membranes are equally incised.

The body is scaleless anterior to a line which runs from the anus forward to a point below and behind the naked pectoral base and then turns dorsally to run by the posterior margin of the opercle to the lateral line. Above the lateral line there are no scales in front of the seventh dorsal spine. The lateral line runs posteriorly from the upper margin of the opercle on 18 to 21 scales with paired external pores, followed by two scales with large single pores. Behind this

point no lateral line pores were observed, probably because of the minute size of the scales and pores.

As in other species of this genus, there are two color phases, barred and plain. The plain pattern is a dull brown with no markings on the body. The dorsal fin has an ocellus on the membrane between the first two spines and a dark band along the outer third of the fin. The anal has a similar submarginal band. The pelvics are dark. Otherwise, the fins are light brown. The head is colored like the body. There is a dark mark on the upper opercular membrane. The supraorbital cirri are slightly darkened.

The barred phase is more common, and there are all stages of intergradation between it and the plain phase. The upper half of the body is light brown, the lower half whitish. Superimposed on this color pattern are ten dark brown bars and nine less distinct intermediate ones, which are especially noticeable anteriorly and ventrally. The fins are similar to those of the plain phase except that the main portions are mottled. The head is also mottled, with a light area from the eye to the base of the pectoral fin and another behind the maxillary. This light area is speckled with dark. The rest of the head is dark and speckled with light. The lower sides appear to be barred dark and light.

This species has been recorded from Misaki, Wakanoura, and Enoura, Japan. Its habitat is said to be clear, warm tidal pools. The maximum standard length observed is under 80 mm. No marked secondary sexual dimorphism has been noted.

Neoclinus uninotatus, sp. nov.

Figures 13 and 14

Neoclinus blanchardi (misidentifications).—Cooper, 1868: 492; Jordan and Gilbert, 1881a: 454; Jordan and Jouy, 1881: 5; Jordan and Gilbert, 1881b: 63; 1883: 761; Jordan, 1885: 909; Eigenmann and Eigenmann, 1892: 357; Eigenmann, 1892: 131, 173; Starks and Morris, 1907: 236; Hubbs, 1927: 364; Jordan, Evermann, and Clark, 1930: 458; Barnhart, 1936: 86, fig. 260.
Neoclinus (*Neoclinus*) *blanchardi* (misidentifications).—Jordan and Evermann, 1896: 467; 1898: 2354.
Neoclinus sp. Hubbs, 1952: 49.

The above synonymy shows that this species heretofore has been called *Neoclinus blanchardi*. Examination of both the type specimen and type description demonstrates that the name

blanchardi belongs to the species which later was named *satiricus*. The following characters used in the type description show this to be true: the mouth very large, extending to below the origin of the dorsal; two cirri over the orbit; and two ocelli on the anterior portion of the dorsal fin. All of these characters are typical of the species called *N. satiricus* by previous authors. *N. uninotatus* has the jaw usually not extending as far posterior as the origin of the dorsal, several cirri with one exceptionally large anterior one over the eye, and one ocellus on

blanchardi and *uninotatus* by their small size at maturity and by their greater number of gill rakers.

The holotype, 124 mm., SU No. 15332, was collected from Newport Bay, California, by George MacGinitie in September, 1947. The following 32 specimens are designated as paratypes: 1 from Capitola, Monterey Bay, California, CAS No. 7557; 1 from Monterey, California, USNM No. 27179; 1 from off Pacific Grove, California, in 10 to 15 fathoms, USNM No. 75158; 10 from Pacific Grove, California,

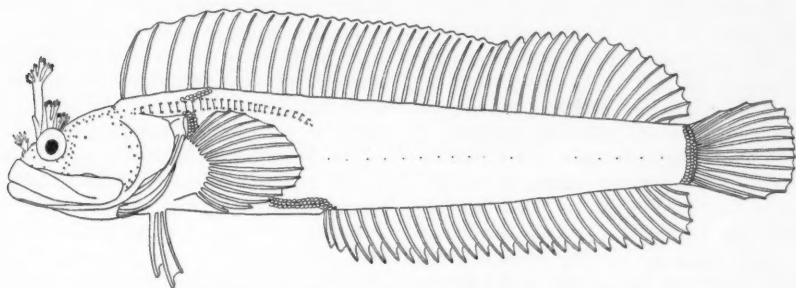


Fig. 13. *Neoclinus uninotatus*, 164-mm. male, from UCLA W50-73.

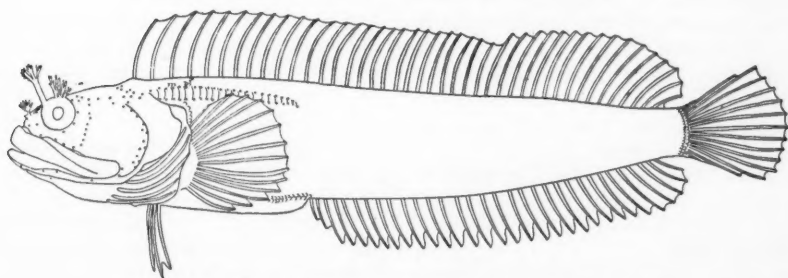


Fig. 14. *Neoclinus uninotatus*, 153-mm. female, from UCLA W50-13.

the anterior portion of the dorsal fin. Examination shows that the type of *blanchardi* is a female and the type of *satiricus* is a male of the same species. The main character used by Girard in the original description to separate *satiricus* from *blanchardi* is the difference in jaw size. Oddly this character not only can separate the males and females of each species but also the species themselves (Fig. 4), which accounts for the error in assuming that Girard described two species rather than the two sexes of a single species. The other two species, *stephensae* and *bryope*, can be separated from

SU No. 2285 and No. 23022 and CAS No. 7414; 1 from Monterey Bay, California, USNM No. 6654; 8 from Santa Barbara, California, SU No. 1445 and USNM Nos. 26883, 26942, 31176, 31209, and 31231; 7 from Santa Monica Pier, California, UCLA Field Nos. W49-113, 435, and W50-13, 72, 73; 1 from Newport Bay, California, UCLA W51-214; and 2 from San Diego Bay, California, including TNHC No. 436.

Vertebrae $14 + 33 = 47$; dorsal XXIII to XXVII (XXV to XXVI), 14 to 17 (15 to 17); anal II, 26 to 31 (27 to 30); total dorsal and

anal rays 69 to 76 (71 to 74); pectorals 14 to 16 (15); anterior lateral-line scales 17 to 26 (22 to 25); gill rakers $4 + 8$ to $10 = 12$ to 14.

The lips are 2.5 times as wide as the sub-orbital. The maxillary extends almost to a point below the anterior base of the spinous dorsal fin in males; and in females to below a point slightly more anterior. The convex inter-orbital is narrow. The cirri are moderate in number: none on the nape, three to eight over the eye, and five to 11 on the anterior nostril. Those over the eye are branched; the anterior is expanded and much longer than the eye.

The convex profile ascends steeply to the eye, then becomes straight and rises gently to the base of the first spine, where it again becomes convex. At the base of the fourth spine the profile begins a gradual decline which does not cease until the caudal peduncle is reached.

The dorsal originates above a point slightly anterior to the posterior margin of the preopercle. The dorsal spines, especially the anterior ones, are flexible. The soft dorsal rays are longer than the posterior spines and the anterior soft rays are as long as the longest spines. The last dorsal ray is bound down by a membrane which is attached to the caudal peduncle anterior to the procurent caudal rays. The first anal spine is two times the inter-orbital width, and is contained 1.2 and 1.6 times in the second spine and first soft ray, respectively. The eleventh ray of the short and rounded pectorals is the longest. The first pelvic soft ray is the shortest. The membrane between the first and second rays is deeply incised and that between the second and third is slightly incised.

Except for a small patch of scales on the anterior pectoral base, the entire body is naked anterior to a line running dorsally from the pelvic fins, behind the pectoral fins, along the opercle, and thence to the fourth dorsal spine. The lateral line runs posteriorly from the upper margin of the opercle on 22 to 25 scales, then drops to the midline, on which it runs to the caudal base. The scales in the anterior section each have a pore above and below the canal. The scales on the posterior section have a single central pore. There are frequently several normal scales between each pair of posterior lateral-line scales.

The color pattern of this species is more con-

sistent than in many other blennies. The ground color of the body is brown, with blackish-brown specklings and inconspicuous silver-blue spangles. The sides are considerably blotched with darker and lighter, to form six dark bands. The belly region is dark purplish-pink. A blue-black ocellus with a bright yellow border is present on the membrane between the first and second dorsal spines (one specimen has a second faint ocellus between the fourteenth and sixteenth spines but none has any trace of an ocellus between the sixth and ninth spines). The dorsal is much blotched with purple-pink and greenish-gilt. It may have darker bands similar to those on the body or half way out on the fin may have a longitudinal cream stripe, which may extend to the base in the center of the fin. The caudal is banded with purple on its anterior two-thirds; its rays are reddish posteriorly. The anal is purplish-red with the tips of the rays light golden. A darkish band is on the outer membranes in preserved specimens. The pectorals are yellowish-pink, with darker marks on the rays; the base is olive with black mottlings. The pelvic is bluish or black with a white tip. The head is black. The sides have considerable gilt. The branchiostegals are bluish toward the margin and, as on the breast region, have dark-bordered blue spots. The cirri are dark at the base and reddish at the tip. The eye has a reddish tinge anterodorsally.

This species is known from San Diego Bay to Capitola, Monterey Bay, California but is not common anywhere in its range. So far as can be determined, none of the specimens has been taken in tide pools. They apparently live on the bottom at a depth of about ten fathoms, varying from seven to 15 fathoms.

Named *uninotatus* for its single dorsal ocellus.

Neoclinus blanchardi Girard

Figures 15 and 16

Neoclinus blanchardi Girard, 1858: 114 (type locality, San Diego, California; holotype, USNM No. 691); 1860: 57; Günther, 1861: 259; Snyder, 1913: 460; Hubbs, 1952: 49.

Neoclinus satiricus Girard, 1860: 57 (type locality, Monterey, California; holotype, USNM No. 7884); Günther, 1861: 260; Jordan and Gilbert, 1881a: 454; Jordan and Jouy, 1881: 5; Jordan and Gilbert, 1881b: 63; 1883: 761; Jordan, 1885: 909; Eigenmann and Eigenmann, 1892: 357; Starks and Morris, 1907: 237; Metz, 1912: 52, figs. 20, 21; Snyder, 1913: 460; Hubbs, 1916: 165; Fowler, 1924: 294; Fitch, 1949: 158.

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Pterognathus satiricus Cooper, 1868: 492; Hubbs, 1927: 365; Jordan, Evermann, and Clark, 1930: 458; Barnhart, 1936: 87, fig. 261.

Neoclinus (Pterognathus) satiricus Jordan and Evermann, 1896: 467; 1898: 2355; 1900: pl. 336, fig. 816.

The holotypes of *Neoclinus blanchardi* (142 mm. USNM No. 691, from San Diego, California) and of *satiricus* (190 mm. USNM No. 7884, from Monterey, California) were ex-

1 from 15 fathoms off Beecher's Bay, Santa Rosa Island, California, UCLA W49-28; 1 from Santa Monica Bay, California, UCLA W49-329; 6 from near San Pedro, California, CAS Nos. 12761, 12795, 12796, and 12965; 2 from Catalina Island, California, CAS No. 20503 and UMMZ No. 94681; 2 from Redondo, California, SU No. 22519; 1 from 14 fathoms off La Jolla, California, SU No. 18425; 1 from

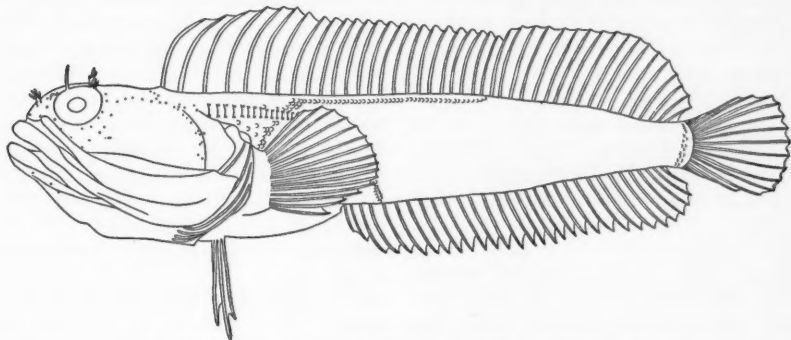


Fig. 15. *Neoclinus blanchardi*, 184-mm. male, from UCLA W49-28.

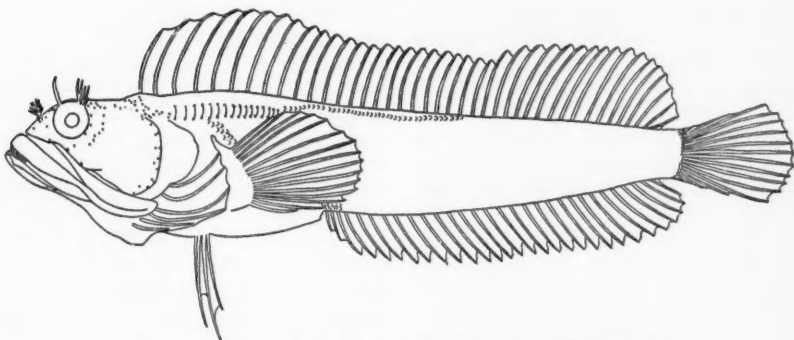


Fig. 16. *Neoclinus blanchardi*, 146-mm. female, from UCLA W49-35.

amined. The following 53 specimens were also examined: 2 from San Francisco?, California, USNM No. 64051; 1 from Monterey, California, USNM No. 27040; 9 from Pacific Grove, California, USNM No. 75454 and SU No. 2288; 1 from Goleta Point, California, UCLA Field No. W49-34; 3 from Santa Barbara, California, SU No. 35281 and UMMZ No. 64174; 1 from 20 fathoms off Santa Barbara, California, UCLA W49-35; 1 from 12 fathoms in Santa Barbara Channel, UMMZ No. 64175;

25 fathoms off La Jolla, California, SU No. 15421; 3 from 33 fathoms off La Jolla, California, CAS No. 20501 and SU No. 15416; 1 from off Point La Jolla, California, UCLA W49-330; 13 from 8 to 15 fathoms off the east coast of South Coronado Island, Baja California, CAS No. 20502, RUC, TNHC No. 435, and NYZS No. 28820; 1 from below Cape Colnett, Baja California, CAS No. 2947; 1 from off San Martín Island, Baja California,

CAS No. 2952; and 2 without locality data, USC.

Vertebrae $14 + 33 = 47$; dorsal XXIII to XXVIII (XXIV to XXV), 15 to 18 (16 to 17); anal II, 26 to 29 (27 to 29); total dorsal and anal rays 68 to 74 (67 to 72); pectoral 14 to 15 (15); anterior lateral line scales 20 to 27 (21 to 25); gill rakers $4 + 8 = 12$.

The width of the lips is contained 1.6 times in that of the suborbital. The maxillary is very much enlarged, especially in adult males, in which it is longer than the head and is attached posteriorly by a very expansive membrane. The interorbital space is broad and W-shaped. The cirri number: none on the nape, one to five over the eye, and one to 13 (one to eight) on the anterior nostril. The longest orbital cirrus is about as long as the eye; all other orbital cirri are less than half as long as the eye. The straight profile ascends steeply as far as the anterior margin of the eye, where it becomes convex and almost level to the occiput, at which point it rises slightly more steeply to the fourth spine. It is then almost level to the base of the soft dorsal, along which it drops gently to the caudal peduncle, on which it is level.

The dorsal originates half way between the posterior margins of the opercle and of the eye. The dorsal spines are all soft and flexible. The soft dorsal rays are higher than the last spines but are slightly shorter than the longest spines. The last dorsal ray is bound down by a membrane attached to the caudal peduncle as far posterior as the procurent caudal rays. The first anal soft ray is twice the first spine. The ninth ray of the short and rounded pectorals is the longest. The third pelvic soft ray is the shortest. The membrane between the first and second rays is deeply incised and that between the second and third is slightly incised.

The belly is naked from the anus to, and including, the pectoral base. There are no scales above the lateral line anterior to the fourth spine; behind it the naked patch along the dorsal grows narrower. The lateral line runs posteriorly on 21 to 25 scales, all of which bear double pores, and then drops to the midline, along which a few single pores extend posteriorly to the caudal.

The life color, as exhibited by fresh specimens, is dull chocolate, with a somewhat reddish glow. The general color is broken near the back

by paler green blotches. The dorsal has green-cream blotches and pinkish splashes on a light-brown base. The edge of the fin is bluish white. The two ocelli on the dorsal are largely metallic blue, becoming black just within the narrow, bright golden yellow ring. The anterior ocellus is between the first two spines and the posterior one is between the sixth and ninth spines. The caudal is dirty green, with the edge broken by dashes of green and red. The anal is splashed with green, pink, and brown, and has a light-cream border. The pectoral is largely brown, with bluish blotches near the base. The upper jaw is pale pinkish brown, with the lower and posterior borders bright yellow. The yellow also extends over the connecting membrane into the mouth and is very conspicuous when the mouth is open. The central part of the mouth is pink. The main supraorbital cirri are sooty, but the posterior cirri and narial flaps are light tan.

After being preserved a day in alcohol, a similarly colored specimen was light tan, with deep brown crossbars. The ground color is light tan with six dark brown saddles and seven lateral blotches; all but the central two and three, respectively, are connected. The ocelli on the dorsal fin are dark with light margins, the anterior is the more distinct but is smaller. Elsewhere the dorsal is brown with a light margin. The light barring on the caudal rays becomes indistinct distally. The anal is light brown proximally, followed by a dark stripe, and has light-tipped rays. The pectorals are light brown; the pelvics, dark brown. The head is dark brown except for the light brown cheeks and a light band on the posterior and ventral edge of the maxillary. Young specimens have only a trace of the anterior ocellus and no sign of the posterior one.

This species has a wide recorded range: from San Martín Island, Baja California, to Monterey, California, and possibly to San Francisco (based on two specimens from San Francisco (?) in the U. S. National Museum). It is found at depths ranging from eight to 33 fathoms. The young are apparently from the shallower water and the adults from deeper water because the adults are recorded from 14 to 33 fathoms and the young from eight to 14.5 fathoms.

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Embryological Head Glands of the Cichlid Fish *Aequidens portalegreensis*

FLOYD J. BRINLEY AND LEROY EULBERG

WHILE studying the development and the nature of spontaneous muscular movement in embryos of a tropical fish, *Aequidens portalegreensis* Hensel (Brinley, 1951), it was noticed that prominent structures appeared on the heads of these embryos prior to hatching and disappeared when the fish started to swim. As these structures are temporary, it was thought that they may be concerned with some embryonic function or associated in some way with the process of hatching.

It is generally known by fish embryologists that the tough firm shell or capsule of the teleost egg becomes soft and pliable at the time of hatching, and that muscular movement of the enclosed embryo assists in its liberation. This softening and dissolving of the shell is due to the secretion of an enzyme into the perivitelline fluid which fills the space between the embryo and the shell (Needham, 1931; Hayes, 1942). Bourdin (1926) presented histological evidence to indicate the presence of secreting cells in the trout embryo. These were single cells found in the ectoderm, in front of and behind the eyes and in the branchial chambers. Two types of cells were described by Bourdin: granular cells which secrete an enzyme and a second type which produces mucus.

In the light of the previous papers, it was deemed of interest to study the morphology and function of the head structures in the embryos of *Aequidens portalegreensis* in relation to hatching. These bodies, or "glands" as they have proven to be, are six in number. Two lie anterior to the eyes (Fig. 1); the remainder are clustered together dorsal to the midbrain and posterior to the eyes (Fig. 2). In the living condition, debris from the cultural media always adheres to the glands from the time of hatching until the larvae begin to swim. When the adherent debris is entangled on the point of a needle or held by fine forceps, the embryo can be pulled through the cultural media. The embryo can be freed by elevating the needle from the culture dish and allowing the surface tension to hold the embryo below the surface

of the water as the needle is pulled away. When the embryos are thus freed from the foreign material and placed in clean water, and the glands are touched with a fine-pointed wood stylus, the embryo can again be pulled and oriented through the water by adherence to the stylus with an invisible sticky substance secreted by the glands. When the water is lightly colored with finely suspended insoluble dye such as congo-red or carmine, the dye sticks to the gelatinous secretion and thus renders it visible. A single strand of extremely elastic mucus can be seen extruding from the center of the gland.

In order to study the histological structures of these glands, embryos were fixed in Bouin's solution, then stained with iron hemotoxylin, hemotoxylin and eosin, or Mallory's triple stain. The specimens were cut in sagittal sections 7 micra thick. All six glands are similar in structure and are ectodermal in origin. They are spherical in contour, about 200 micra in diameter, and consist of a single layer of many columnar cells radiating from the basement membrane and terminating at a flask-shaped lumen which opens to the surface through a minute pore (Fig. 3.). The nucleus lies in the basal end of the cell adjacent to the basement membrane, and contains dark-staining granules within a prominent membrane. The light-staining cytoplasm appears to be free of granules. The cells are closely packed together and a view through the lumen at the background cells shows them to be in the shape of a curved honeycomb.

These glands have not been observed by the authors in other fishes such as rainbow trout (*Salmo gairdneri*), northern pike (*Esox lucius*) or killifish (*Fundulus heteroclitus*).

There seems to be no question that these multi-cellular glands secrete mucus prior to hatching and continue to function until they disappear. Prior to hatching, the secretion of mucus into the perivitelline liquid increases the viscosity and density of the fluid so that the embryo will float freely and not adhere to the

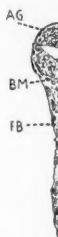


Fig. 1. *Aequidens portalegreensis*, MB, r. gland; BV, bl.

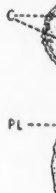


Fig. 2. showing dorsal pigment muscle

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shell under the influence of gravity. The presence of gelatinous material in the perivitelline

of shell from the egg, and observing the viscous fluid surrounding the embryo.

Wintrebert and Hayes (cited by Needham, 1931) reported that the hatching enzymes were often sufficiently powerful to kill the embryo by auto-digestion prior to hatching, or so weaken it that it died in an early larval stage. It is possible that the mucus in the perivitelline fluid minimizes the digestion of the embryo by the hatching enzymes.

In the laboratory the eggs are deposited in or on a flower pot placed in the aquarium. In

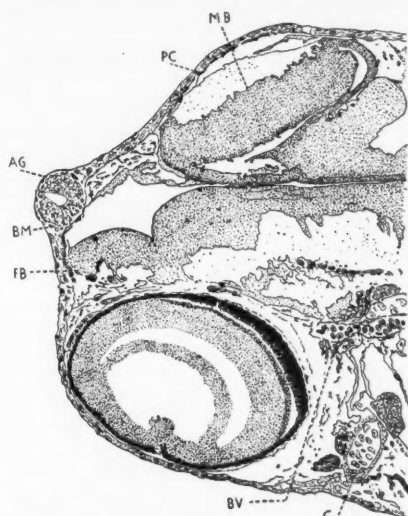


Fig. 1. Mesial sagittal section of *Aequidens portalegreensis* showing location of anterior gland. MB, mid-brain; PC, pigment cells; AG, anterior gland; BM, basement membrane; FB, forebrain; BV, blood vessel; C, cartilage.

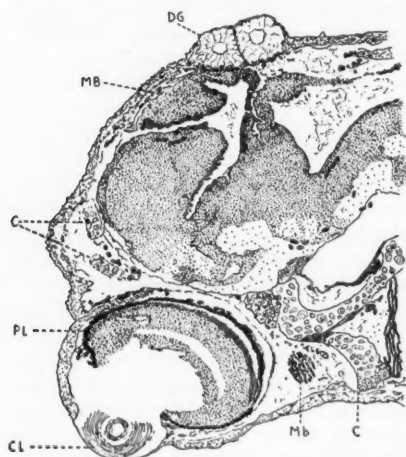


Fig. 2. Lateral sagittal section of *A. portalegreensis* showing location of one pair of dorsal glands. DG, dorsal glands; MB, mid-brain; C, cartilage; PL, pigment layer of eye; CL, crystalline lens; Mb, muscle bundle.

fluid can be demonstrated by cutting the shell with fine-pointed scissors, pulling the cut pieces

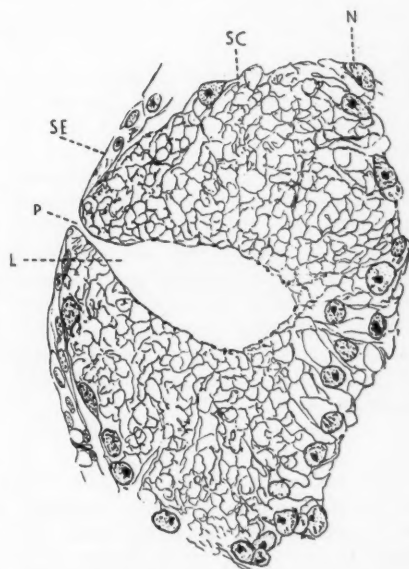


Fig. 3. Anterior gland of Fig. 1. Camera lucida, $\times 450$. N, nucleus; SC, secretory cells; SE, superficial ectoderm; P, pore; L, lumen.

nature the eggs would likely be placed on stones. After two or three days, the embryos are removed from the pot by the parents. In removing the embryos, the shells are ruptured and the naked organisms are placed in a small cavity in the sand. It is possible that the gelatinous mucus adheres the embryos to the sand grains and thus prevents them from being fanned from the colony by water currents created by the fins of the guarding parents. The lack of granules in the cytoplasm of the glandular cells leads to the suggestion that these glands do not secrete enzymes.

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Breeding Habits of the Percid Fish *Hadropterus copelandi* in Michigan¹

HOWARD ELLIOTT WINN

DESPITE the fact that the darters are one of the most abundantly represented groups of fishes in eastern North America, little is known of their behavior. The meager literature on life histories has been summarized by Raney and Lachner (1939). While attending the 1951 summer session of the University of Michigan Biological Station, the opportunity was presented to study the habits of the channel darter, *Hadropterus copelandi* (Jordan). Like several other darters, this species was found to have a simple breeding pattern, which consists of free scattering of the eggs over gravel with no parental care.

GENERIC STATUS

The reference of *copelandi* to *Hadropterus* rather than to a monotypic genus, *Cottogaster*, was recommended by Reeve M. Bailey, who (1951) proposed a number of changes in the generic arrangement of the darters. At his suggestion, the author has studied the supposed generic characters in order to test this proposal.

Hubbs (1926 and 1930) and Hubbs and Greene (1928) have published reasons for the assignment of this species to *Cottogaster*. The differences in breeding coloration between *copelandi* and the forms of *Hadropterus* are no greater than among species of what classically has been considered the genus *Hadropterus*. The overall body pattern and the similarity of dark blotches along the side link *copelandi* closely with other species of *Hadropterus*. Differences in body proportions, sharpness of

snout, and squamation may be dismissed as of specific value only. The characters of *copelandi* considered most important as a basis for recognizing *Cottogaster* (Hubbs, 1930) were the absence of a frenum, the rudimentary air bladder, the projection of the snout beyond the premaxilla, the horizontal mouth, and the moderately flexible anal spines.

All degrees of development between a large premaxillary frenum and a deep groove occur in populations of *H. copelandi*. In combined collections the data may be grouped as follows: New York—8 with and 17 without a frenum; Ontario—8 with and 26 without; Michigan—21 with and 116 without; Tennessee—5 without; Arkansas—29 without; Oklahoma—2 with (frenum very weak) and 52 without; Kansas—1 with and 12 without. Thus, of a total of 297 specimens, 40 or 13 percent have a frenum.

The size of the air bladder is also subject to considerable variation, which may indicate that some populations of *copelandi* are in the process of losing this organ. The length of the air bladder enters the head length from 2.7 to 6.0 times in 13 specimens from Michigan. At least three have air bladders which cannot aptly be called rudimentary. The structure may perhaps best be described as variably reduced. In five specimens from Oklahoma the ratio varies from 1.3 to 2.8. The air bladder is larger than in 6 of 10 examples of *Hadropterus shumardi* Girard examined, about the same size as in 2 specimens of *H. wanidea* (Jordan and Gilbert), and almost as large as in some individuals of *H. maculatus* (Girard). Five specimens of *copelandi* from Tennessee also showed much variation in the length of the air bladder. The above

¹ Contribution from the Biological Station and the Museum of Zoology, University of Michigan.

relationship is not explicable on the basis of size, for wide variation is present in fish of all lengths examined.

The form of the snout and mouth are also variable. Of 29 specimens from the Cheboygan River, 12 have the snout projecting slightly beyond the premaxillae, in 10 these structures are equal, and in 7 the premaxillae protrude slightly. In populations examined from other regions a somewhat smaller percentage have the premaxillae terminal. The mouth is usually slightly oblique, rather than horizontal, but this can scarcely be regarded as a generic character. Some species in *Hadropterus* have the anal spines more flexible and some less flexible, but in view of a rather wide range of flexibility in one population of *copelandi* this is too unreliable a character to be considered of systematic importance.

A review of these supposed differential features thus reveals none to be of high consistency or notable distinctiveness. On the other hand *copelandi* shares with *Hadropterus* the modified row of mid-ventral scales, exhibits a similar color pattern of broad bars or blotches, has a fairly large anal fin, the body is usually elongate and little compressed, and in other characters this species is clearly related to the fishes of that genus.

SPAWNING SITE REQUIREMENTS AND ASSOCIATES

The study area (Fig. 1) is on the Cheboygan River, below a power dam and a pulp mill in the city of Cheboygan, Cheboygan County, Michigan, about one mile above the river's mouth in Lake Huron. The habitat agrees with the statement that in the Great Lakes region this darter lives in the main lakes and in the lower parts of the main tributaries (Hubbs and Lagler, 1947: 87).

The spawning ground (Fig. 1) lay along the inside of a bend in an area about 10 feet wide and 300 feet long in water from $1\frac{1}{2}$ to 5 feet deep. The river at this point was about 100 feet wide and was characterized by a swift current, which exhibited considerable horizontal and vertical variation. The average of two surface readings with a Gurley Current Meter was 1.4 feet per second whereas the average of four readings from about three inches above the bottom, in water between 2 and 3 feet deep,

was 0.95 feet per second. The substratum contained a mixture of rocks, gravel, and sand. Behind rocks the flow could not be determined because the current was turbulent and often flowed upstream. Other possible breeding areas above and below the dam were investigated for signs of breeding activity, but apparently none was utilized. The dam probably serves as an upstream barrier and other sites below the dam presumably did not meet the spawning requirements. It seems likely that the breeding aggre-

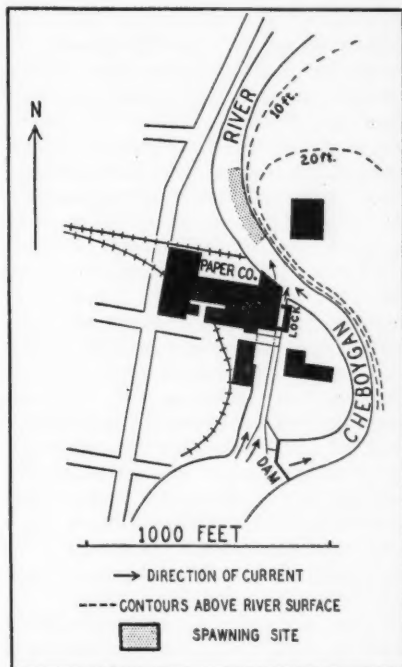


Fig. 1. Map of the spawning area of *Hadropterus copelandi*.

gation results from an upstream migration from Lake Huron. A small population has been recorded in the past below a dam on the Black River, tributary to the Cheboygan River.

The shore near the spawning area formed a high clay bank (Fig. 1) covered with grass and shrubs, but directly upstream from the breeding ground, this bank was bare and eroding. The adjacent shoal of the river seemed to have the current and depth required for spawning, but the rocks and gravel of the bottom were

largely covered by soft clay. This sediment probably prevented the darters from extending their breeding activities over it. Below the spawning area, the limiting factors were less apparent. The current and substratum seemed to be adequate. The water along the shore was shallow, deepening gradually until it dropped off steeply to more than 5 feet. *Etheostoma nigrum* (Rafinesque) was very common over this area. Perhaps competition with that species, depth of water, or both factors excluded the breeding population of *Hadropterus copelandi* from this area.

Breeding activity was intermittently prevented by variations in the flow of water through the pulp mill. At times for a period of from 5 to 30 minutes, the flow from the mill was so modified that the current over the lower third of the breeding ground was much reduced, and an eddy resulted in reversal of flow. In the middle third the current was of normal direction but considerably slowed, whereas in the upper part there was little if any change. When the flow was thus modified, most of the breeding darters on the lower and middle sections stopped all courtship activity to swim into the deeper water of the river. Those few that remained perched on rocks or swam sporadically with no attempt to spawn or feed. This indicates that there is a minimum threshold for water movement below which courtship and spawning are inhibited. Other physical and chemical factors characteristic of flowing water and important to fish apparently would not be so abruptly affected. When placed in aquaria simulating natural conditions as nearly as possible, but with a slow current, breeding adults were active and healthy, but did not spawn. It would prove interesting to study breeding fish in a stream subject to experimental control where only the rate of flow is varied and where the various microcurrents could be determined with precision.

Along the upper two-thirds of the breeding ground, there was an abrupt drop off from the shoreline to a depth of about one foot. The lower third had a narrow sloping shore zone with some aquatic vegetation (*Scirpus* and *Chara*). In this zone *Etheostoma nigrum* was observed commonly, but very seldom did it range out into the area of *H. copelandi*, which spawned in water between $1\frac{1}{2}$ and 5 feet deep

—most frequently from 2 to 3 feet. The only general point of contact seemed to be the shallowest range of *H. copelandi* and the deepest range of *E. nigrum*, a foot outside the vegetation zone. Until more such areas are observed it will be impossible to identify with greater exactness the factor or factors limiting the spawning areas of this species. Ultimately the role of the various environmental factors should be tested in the laboratory.

Notropis volucellus (Cope) and *Percina caprodes* (Rafinesque) were the only other fishes commonly observed over the spawning area. Only the latter species lived on the bottom with the channel darter.

TERRITORIALITY AND SPAWNING

Observations of the spawning activities were made between July 9 and 23. The males maintained territories, the center of which was always located behind one or more rocks from about four inches in diameter to many times that size. Most of their time was spent behind these rocks where the current was irregular and usually flowed backward so that the fish seemingly oriented themselves downstream. The general flow could be determined by watching small pieces of debris in the water. Territories were actively defended against other males of *H. copelandi*, but not against *Percina caprodes*, which often crossed the territories. At such times the guarding male always swam out of the path of the logperch. At frequent intervals the males left the center to travel three or four feet away, occasionally even farther, but they always returned immediately to their place behind a rock. If a female was encountered within a radius of three or four feet from the center of a territory, the male chased her and sometimes apparently attempted to drive her toward the center. Some territories were more restricted; the size seemed to depend entirely on the proximity of other males' holdings. In an area of 10 by 30 feet, which represented the region of greatest concentration, thirty territories were counted near the peak of the spawning season.

Females moved promiscuously over various territories spawning with many males. A large number of attempted mountings by the males was observed. Actual spawning, in the five or six times it was observed, occurred anywhere

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within the male's territory. It took place between small rocks or in the fine gravel behind large rocks, but never in fine sand. The male perched on top of the female embracing her on each side with his pelvic fins and with his caudal fin beside the female's caudal fin. This seems to be the same position found and figured by Petravicz (1938) for *H. maculatus*, although I could not verify whether the anal and the caudal fins were on opposite sides of the female. After the male mounted, the female vibrated vigorously for a few seconds, at which time the eggs were laid and fertilized. Following this type of behavior by the fish, the author scooped the eggs out of the gravel. As nearly as could be determined by this method, four to ten eggs were laid at a time. The adults do not care for the eggs after deposition.

Spawning took place at temperatures between 69° and 72° F. The Cheboygan River flows out of Mullet Lake, a large lake only a few miles above the study area, and therefore is subject to minor daily fluctuations. On June 22, 1951, 7 males and 3 females were seined in water of 68° F. The females contained many large, white eggs which indicated that they were not ripe. Ripe eggs, transparent and with the oil globules observable, were stripped from females caught on July 2 at 69° F. The temperature gradually increased to 72° F. when, on July 25, only a few males were maintaining territories. A few females taken two days later were spent. On August 8, no channel darters were observed over the spawning grounds or anywhere along the shore in that vicinity.

EGGS

The slightly adhesive and demersal eggs are oddly shaped, with a tendency to be flattened in one plane. The egg is partially transparent with an orange oil globule, in contrast to many other darter eggs which in total appearance are yellow. The average maximum diameter of four eggs preserved in 10 percent formalin was 1.4 mm., but there was considerable variation.

Some eggs, maintained for seven days after artificial fertilization, attained the eyed stage, and movements of the embryo were evident before death resulted from fungus infection.

SEXUAL DIMORPHISM

Although the breeding color of *H. copelandi* is less brilliant than in some other darters, it is

nevertheless striking. In the females the fins are translucent except for a few, small isolated chromatophores on the caudal fin and on the base of the pectoral fin; the rays of both dorsals contain a few irregular gray spots, and the interspinous membranes are gray at the base. The base of the pectoral and the posterior three or four rays of the pelvic are cream colored. From the lower jaw to the caudal peduncle, the ventral half of the body is essentially white. There is a distinctive midlateral series of about 10 to 12 olive-black blotches; the anterior two or three are smaller and less distinct than the rest. The blotches are separated by creamy interspaces, and two cream spots are evident at the base of the caudal fin. Above the lateral markings the margins of the scales are outlined in black. These lines are intensified on some scales to produce a slightly mottled effect and 3 to 6 faint saddles. Those saddles in front of the first dorsal, between the dorsals, and at the middle of the second dorsal are most clearly apparent in life. There is a glistening gold spot on the lower part of the operculum, in front of which the cheek is white with gray speckles. A faint gray and yellow suborbital bar is noticeable. The upper half of the operculum is darker gray and a faint black bar extends downward and backward from the eye. The top of the snout is dark gray, edged laterally with black.

The male exhibits the essential pattern of the female, but is much more heavily pigmented. The black pelvic fins and the color and fusion of the lateral blotches are especially distinctive. The creamy interspaces between the lateral blotches of the female are lacking and the lateral bars are almost indistinguishably fused into a dark lateral band that has a decidedly pale, blue-green hue. Dorsally this color extends slightly above the lateral band; ventrally it fades into an indistinct olive-green, which approaches the midline in the region of the anus. The blue-green is intensified between the base of the pectorals and the gill aperture. The basal portion of the membranes of the anal fin is dusky. The pelvic membranes are very black, especially between the first four rays and at the base of the fin, whereas the outer margin is white. The dorsals are dark gray, the spinous one darker along the basal half and followed by a light band, then a narrow dark band, and

finally by a white edging. In some individuals the pectoral has considerable pigment, but never as much as the pelvic. The space under the eye from the tip of the snout to the posterior part of the operculum is much darker than in the female, so that the suborbital bar is indistinct. The ventral half of the body is speckled with gray, most intensely from the base of the pelvic fins to the tip of the lower jaw. In the more brilliant males, the under part of the chin is milky-blue dotted with gray. Two blackish spots are evident in front of the branchiostegal membranes.

The pelvic spine of the male is moderately thickened, much like that described by Petrávicz (1938) for *H. maculatus*. A row of modified midventral scales is found in the male from between the pelvics to the anus. In the female the modification is slight. The function of these scales has not been determined. Nuptial tubercles are not present in this species.

FOOD AND FEEDING

It appeared from observation that this darter fed upon bottom organisms in places between and behind rocks where considerable agitation of the sand took place. The high number of chironomids in the diet (see below) provided confirmation. When the observer walked upstream, a few channel darters would gather below to feed on animals dislodged from the bottom. A small school of *Percina caprodes* usually would do the same thing. It was also interesting to watch *Percina* employ the snout to push over rocks two or three inches in diameter in order to obtain food. *H. copelandi* was never seen to engage in this activity. Undoubtedly *Percina* ate some of the eggs of the channel darter because the logperch was often seen feeding in the gravel where spawning had been completed a few minutes earlier.

The stomach contents of eight adult channel darters are as follows: 20 chironomid larvae, 3

cladoceran (?) shells, 1 insect larva, small amount unidentifiable; 18 chironomids, 1 cladoceran (?) shell; 2 chironomids, some remains unidentifiable; 36 chironomids, 2 dipterous larvae, about 20 percent (by volume) unidentifiable; 20 chironomids, 1 trichopterous larva, about 10 percent unidentifiable; 10 chironomids, 3 cladoceran (?) shells, about 30 percent unidentifiable; 9 chironomids, 2 trichopterous larva, about 50 percent unidentifiable; and 22 chironomids, 1 trichopterous larva, and 10 percent unidentifiable.

I am indebted to Dr. Charles W. Creaser for valuable suggestions, and to Dr. Reeve M. Bailey for criticism of the manuscript. Carolyn Winn was of constant help both with the field work and the writing of the manuscript. Ann Dittlinger helped with much of the seining.

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Some General Considerations of the Problem of Poisonous Fishes and Ichthyosarcotoxism¹

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THE PROBLEM of poisonous fishes has been consistently neglected by ichthyologists and public health workers. With the expansion and development of shore fisheries in the tropical Pacific, poisonous fishes will become increasingly significant. The problem at this time is primarily an epidemiological one. A toxic species in one region may be commercially valuable in another—a situation which has resulted in considerable confusion. Concise knowledge of the taxonomy and biology of poisonous fishes is requisite if future studies regarding the physical and pharmacological properties of the toxins are to be of practical significance. The economic and military significance of such fishes is well established and the need for basic research is incontestable.

The purpose of this paper is to briefly review the present status of the poisonous fish problem and to clarify the terminology relating to the disease.

HISTORICAL BACKGROUND.—One of the earliest accounts of fish poisoning was written by Peter Martyr, the first historian of the West Indies, in 1530 (cited by Gudger 1930: 47). According to Suehiro (1947: 140) puffer poisoning has been known in the Orient since ancient times. One of the earliest Chinese records was written by Fijichin in the publication, *Honsho Kamoku*, in 1590. In reference to the puffer, Rijichin stated that "... its liver contains a violent poison." Numerous other accounts regarding puffer poisoning and tetraodontoxin have appeared in ancient and modern Japanese literature. Unfortunately, the bulk of these papers is not readily available to American researchers. The bibliographies by Suehiro (1947) and Yudkin (1944) are excellent for a historical review of the literature dealing with poisoning by puffers.

Anderson (1776) is usually credited with the first published account of ichthyosarcotoxism in the tropical Pacific. Some of the best general reviews on the subject of poisonous fishes are

by Calmette (1908), Phisalix (1922), Pawlowsky (1927) and Whitley (1943). Reports dealing specifically with ciguatera are by Gudger (1930) and Arcisz (1950). Hiyama (1943) reported on the poisonous fishes of Micronesia. An investigation of the poisonous fish fauna of the Phoenix Islands was recently conducted by Halstead and Bunker (In press). With the exception of the investigations of Japanese workers on tetraodontoxin, there is no data available relative to the chemical and pharmacological properties of fish poisons.

THEORIES ON THE CAUSE OF FISH POISONING.—Numerous theories have been propounded as to the cause of ichthyosarcotoxism. The following are those most commonly presented:

1. Copper-contaminated water resulting from shipwrecks, war matériels, or natural occurring copper deposits.
2. Manchineel berries, *Hippomane mancinella*.
3. Poisonous marine invertebrates, e.g., dinoflagellates, jellyfish, corals, swarming palolo worms, mollusks, crabs, etc.
4. Poisonous algae.
5. Chemical contamination of the water by matériels containing nitrocellulose and other chemicals aside from copper.
6. Bacterial contamination of the flesh of the fish.
7. Physiological changes within the body of the fish, e.g., during the reproductive period.

The time-worn theories regarding copper poisoning and manchineel berries are in disrepute and without scientific basis. The studies of Costa Mandry (1928: 133-34; 1933: 56; 1940: 211-14), Lee and Pang (1945: 282), Yasukawa (1950: 194-95), Hiyama (1950: 13-15) and Arcisz (1950: 12-15), which were conducted in both the Caribbean and tropical Pacific, fail to support the bacterial-origin theory. Moreover the clinical picture of ichthyosarcotoxism differs considerably from any type of bacterial food poisoning that has been described to date. The symptoms resulting from bacterial food poisoning, with the exception of botulism, are primarily gastro-intestinal. The sensory disturbances, which are routinely present in ichthyosarcotoxism, are absent in bacterial intoxications. In most

¹ This investigation was supported by a research grant from the Division of Research Grants and Fellowships, of the National Institutes of Health, Public Health Service and a contract from the Office of Naval Research, Department of the Navy (Contract No. NONR-205(00)).

types of food poisoning the recovery period is usually within 6 to 48 hours. The recovery period in fish poisoning is extremely variable—from 48 hours to 4 weeks. In some instances the patient complains of weakness and mild transient sensory disturbances for many weeks after the initial attack has occurred. Since a detailed discussion of the clinical characteristics of the disease will appear elsewhere, further mention of the symptomatology will not be made here.

Ross (1947: 620) is of the opinion that the dumping of war matériels has some bearing on the increased incidence of fish poisoning in certain localities. For example, some of the fishes which were commercially valuable species, i.e., seabass, cavallas, snapper, and were commonly eaten without ill-effect at Fanning Island until 1945, have since become poisonous. However, it is also established that ichthyosarcotoxism had existed in various other areas in the tropical Pacific for many decades prior to World War II. The peculiar spotty geographical distribution of the disease suggests that this is a food-chain problem. The relationship of marine invertebrates and algae to poisonous fishes is not understood, since analyses of the stomach contents of these fishes have never been conducted.

TERMINOLOGY.—The term "poisonous fishes" refers to fishes whose flesh when ingested by humans produces various gastro-intestinal and neurological disturbances. This form of intoxication is a distinct clinical entity and is not related to the ordinary type of bacterial food poisoning. "Venomous fishes" produce their injurious effects by injecting their venom by means of spines, stings or "teeth." Intoxication of this latter type is associated with mechanical trauma. Hence, the terms "poisonous" and "venomous" fishes are not interchangeable. In some instances, e.g., the surgeonfish, a fish may be both "poisonous" and "venomous," since certain species are not only armed with venomous spines but have poisonous flesh as well.

"Ichthyotoxism" is a general clinical term which, according to most authors, includes the forms of intoxication resulting from both "poisonous" and "venomous" fishes. In an attempt to clarify the confusion that inevitably

results from such generalizations, the following nomenclature and classification is proposed:

Ichthyotoxism is the general term which should be used to include the forms of intoxication resulting from contact with both "poisonous" and "venomous" fishes. This term should not be used to designate bacterial food poisoning which on occasion may be associated with ingestion of contaminated fish flesh. *Ichthyotoxism* may be of two types:

- (a) *Ichthyosarcotoxism* (Gr. *ichthys*, a fish; *sarkos*, flesh; *toxikon*, poison): The specific term used to designate intoxication resulting from the ingestion of the flesh of poisonous fishes. The poisons involved would be termed *ichthyosarcotoxins*.
- (b) *Ichthyocanthotoxism* (Gr. *akantha*, a thorn or prickle): The specific term used to designate intoxication resulting from injuries produced by the stings, spines or "teeth" of venomous fishes. The poisons involved would be termed *ichthyocanthotoxins*.

Fish poisoning has been variously designated as ciguatera, Pacific type of ichthyotoxism, and "tetrodon," puffer, globefish or fugu poisoning. All of these terms come under the heading of ichthyosarcotoxism. The word ciguatera originated with the early Spanish settlers of Cuba (Gudger 1930: 47; Arcisz 1950: 1), who used it in reference to the neurological and gastro-intestinal disturbances resulting from the ingestion of the marine snail, *Turbo pica*, commonly known as cigua. The disease resulting from the ingestion of the cigua was called ciguatera. Gradually the term was expanded to include both mollusc and fish poisoning. Ciguatera generally refers to ichthyosarcotoxism as found in the Caribbean area, and this is the preferred usage of the term, even though some authors have used it as a synonym for fish poisoning, regardless of the geographical location of the disease.

The terms "tetrodon" fugu, globefish, toadfish, toado, and puffer poisoning are synonymous, but their use is restricted to forms of intoxication resulting from the ingestion of fishes belonging to the suborder Tetraodontoidea, which comprises the puffers and porcupine fishes. The designation "tetrodon" poisoning comes from the misspelling of the puffer

genus, *Tetrodon*. The term is used in the literature to the confusion of this and the common designation, termed

ACKNOWLEDGMENT: Dr. L. R. A. for criticism

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genus, *Tetraodon*. Taxonomists have relegated *Tetrodon* to synonymy, but this misspelled term is still deeply entrenched in medical literature. The author recommends the use of the correct spelling, *tetraodon*, when referring to this type of poisoning. The word "fugu" is the common name used by the Japanese to designate the puffer. The poison would be termed *tetraodon* toxin or puffer poison.

ACKNOWLEDGMENTS.—The author is indebted to Mr. E. C. Jaeger, Mr. R. R. Ocampo, Dr. L. P. Schultz, Dr. S. S. Berry, and Dr. R. A. Mortensen for helpful suggestions and for criticisms of the manuscript.

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A New Boxturtle from the Pleistocene of Southwestern Kansas

THOMAS M. OELRICH

THE existence of a warm interglacial fauna in southwestern Kansas during the Pleistocene is indicated by the remains of a large boxturtle. Its occurrence extends the geographic range of the *Terrapene carolina* group to the northwest, and is also a northwestward extension of the known range of the Pleistocene genus *Terrapene*.

The major part of the specimen was collected in the summer of 1950 by one of the field parties of the Museum of Paleontology of the Univer-

sity of Michigan under the direction of Dr. Claude W. Hibbard; other members of the party were James Rogers, Thomas Sparrow, Dwight Taylor, and the author. Fragments of the specimen, however, had been found the previous year by Irving Vogt of Meade, Kansas.

The author is indebted to Dr. Hibbard for guidance throughout the preparation of the manuscript. Appreciation is extended to Dr. Norman E. Hartweg, of the Museum of Zoology of the University of Michigan, for his sugges-

tions and for the loan of a series of Recent turtle specimens and skeletal material which were used for comparison with the fossil specimen; to Dr. David H. Dunkle, of the United States National Museum, for permission to study numerous fossil specimens of *Terrapene*, and to Dr. George Gaylord Simpson, of the American Museum of Natural History, for the loan of a fossil turtle. Gratitude is also expressed to Messrs. Horace G. Adams II and Horace G. Adams III for their generosity in allowing the excavation of this specimen from their property.

HISTORY OF FOSSIL MEMBERS OF THE GENUS *Terrapene*

Few species of fossil boxturtles have been described from North America. Most of them are from the Pleistocene and the majority of the Pleistocene specimens have been from Florida and Texas. The others were isolated finds in Maryland, Indiana, Pennsylvania, and New Mexico.

Two species of boxturtles have been described from the Pliocene: one from Florida, the other from Kansas. One of these, *Terrapene putnami* Hay, 1906, was dredged from the Alfi River in Florida. It is distinguished by its large size and the thickness of its plastron and carapace; the thickness of the hypoplastron is nearly one-third of its length. This turtle does not resemble any of the living species. The other, *Terrapene longinsulae* Hay, 1908b, from the Lower Pliocene of Long Island, Phillips County, Kansas, is a nearly complete plastron and carapace with a skull, but it is an aberrant specimen in both osteological characters and scutellation. Hay said that it resembled *T. ornata* (Agassiz) more than *T. carolina* (Linnaeus) in being broader and not having a median carina. The specimen is almost identical in size and shape with the Recent *T. ornata*.

Of the Pleistocene forms, Hay described *Terrapene canaliculata* (1907), *T. formosa*, *T. antipex*, and *T. inoxia* (1916b) from Florida. C. W. Gilmore (1927), when he described a new boxturtle, *T. singletoni*, made *T. antipex* synonymous with *T. canaliculata* and showed that the differences between them were merely those of degree. The type of *T. antipex*, No. 8820, United States National Museum, is only a posterior lobe of the plastron; it could not be distinguished from a large number of posterior

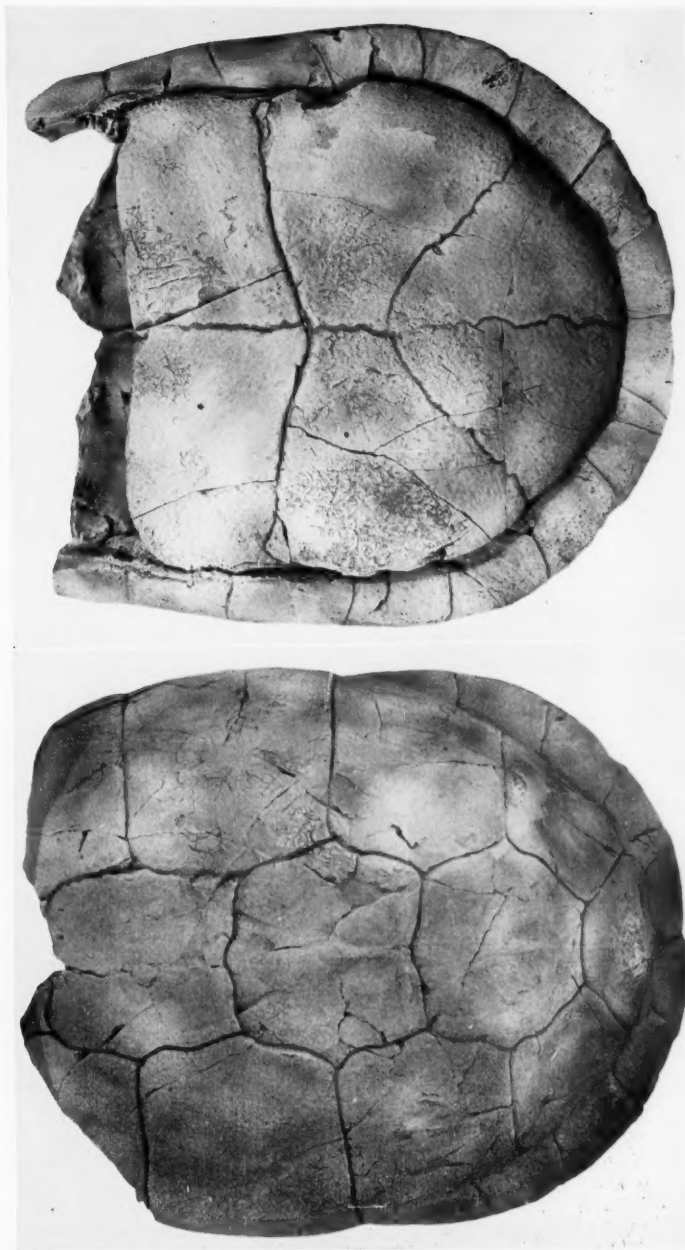
plastral lobes of *T. canaliculata* which were examined.

Barbour and Stetson (1931) revised the Pleistocene boxturtles from Florida and considered that *Terrapene canaliculata*, *T. formosa*, *T. inoxia*, and *T. singletoni* could be duplicated among the variations of an extensive series of Recent *Terrapene major* (Agassiz). They stated that, "*T. major* is generally considered to be the direct descendent of the Pleistocene form [*T. canaliculata* as it pre-dates all other names]. It differs in no way, except in size, as far as the carapace goes. . . . Variations of shape and proportion, in themselves alone, are not sufficient to warrant the erection of new species." The characters which may be assigned to *T. canaliculata* are a broad carapace, a distinct dorsal carina, a well-developed lateral keel, strongly flaring peripherals, and an urn-shaped first vertebral. The vertebral scutes are narrow and the carapace is about twice the size of Recent species.

After examining the types and other more complete specimens of *T. canaliculata*, *T. singletoni*, *T. formosa*, and *T. inoxia*, the author finds it hard to believe that these can all be synonymous with *T. canaliculata* as suggested by Barbour and Stetson. *T. canaliculata* is distinct in its breadth, its large size, its dorsal and lateral keels, and in the thickness of its carapace. *T. singletoni* can at once be distinguished by its elongation, its smooth surface, its narrow vertebral series, and the thickness of its carapace. These characters are consistent in the three specimens examined, USNM 11838 (the type), 11181, and 11913. The types of *T. inoxia* and *T. formosa*, although very small specimens, are both distinctive and obviously immature.

Cope (1869) described a boxturtle from the Maryland Pleistocene as *Cistudo eurypygia*. It is characterized by its general resemblance to *Terrapene carolina*, but differs from it specifically in that the tenth peripheral scute borders the fifth vertebral. Cope (1889) described a specimen as *Toxaspis anguillulatus* from the Port Kennedy Bone Bed in Pennsylvania. Hay (1902b) placed *Cistudo* and *Toxaspis* in the genus *Terrapene* Merrem. Later (1908a) he placed *T. anguillulatus* in synonymy with *T. eurypygia*.

Four species of boxturtles have been described from the Pleistocene of Texas. *Cistudo marnochi*



Terrapene llanensis Oelrich, sp. nov.

Upper: Ventral view of holotype, No. 26957, Museum of Paleontology, University of Michigan.

Lower: Dorsal view of same specimen.



Lone Tree Arroyo, the locality of *Terrapene llanensis*
 Upper: Locality UM-K2-47, T34S, R29W, Sec. 32, Meade County, Kansas. The arrow indicates where the specimen was found.
 Lower: Upstream from locality UM-K2-47. The arrow indicates the contact of the Pleistocene stream deposit with the overlying alluvium.

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Cope (1878) is known from a posterior lobe of the plastron and, as described by Cope, is entirely flat on its ventral surface. The specimen is lost. Hay located in the Cope collection a specimen of a carapace which he referred to *T. marnochi* (1908a), and suggested that it resembles the Recent *T. major*.

Hay (1916a) described a species of boxturtle from Austin, Texas as *Terrapene whitneyi*, and wrote that its "carapace [is] broad and high; with broad vertebral scutes and with no dorsal keel. Plastron with lateral hinges equal to one third of the length of the hind lobe; femoral half as long as abdominal; and one half the length of the hind lobe." The description of the posterior lobe of the plastron resembles that of the type of Cope's *T. marnochi*.

Hay (1920) described *Terrapene bulverdei* from fragmentary remains of several individuals. The fifth vertebral scute in these specimens was described as being wider than any of the preceding vertebrals. At the present time these fragmentary remains of the type of *Terrapene bulverdei*, USNM 9221, do not have a complete fifth vertebral. They resemble *T. whitneyi*. Associated with them is a xiphiplastral element which is somewhat pointed and resembles that of "*Terrapene antipex*" (*T. canaliculata* of Gilmore). Both are small turtles comparable in size to Recent species.

Hay (1924) described and figured a fragmentary boxturtle, *Terrapene impensa*. The holotype is a small elongate anterior lobe of the plastron. It is characterized by deep sulci separating the scutes. Earlier, in 1911, he had recorded a fossil specimen of *Terrapene carolina* from post-Wisconsin Pleistocene deposits of Laurence County, Indiana. He said that it differed in no way from individuals of *T. carolina* then living in that locality. The specimen is a natural mold.

Stock and Bode (1936) recorded a fossil specimen of *Terrapene ornata* from post-Wisconsin Pleistocene deposits at Clovis, New Mexico, that is identical with the living species. Simpson (1945) recorded *Terrapene canaliculata* from near Enon, Moniteau County, Missouri. Upon examination of this turtle, however, it was found to be a specimen of *Emys blandingi* (Holbrook).

The present form is different from all those recorded above, and herein is described as new.

Terrapene llanensis, sp. nov.
(Pl. I; Fig. 1)

HOLOTYPE.—No. 26957, Museum of Paleontology, University of Michigan, consists of the posterior four-fifths of the carapace and the posterior lobe of the plastron. There are in addition elements of the appendicular skeleton consisting of two sacral ribs, two ilia and parts of two pubes, a right and left femur, a tibia and fibula, and parts of one scapula.

The specimen was collected by a University of Michigan field party on July 28, 1950. Parts of the same specimen had been collected the previous year in the bed of the stream by Irving Vogt, a local rancher.

HORIZON AND TYPE LOCALITY.—Sangamon, late Pleistocene. The specimen was taken on a tributary of Shorts Creek, as shown on the U. S. Topographic Map of 1892. This creek is known locally as Lone Tree Arroyo. The locality, UM-K2-47, is located on the XI Ranch in T34S, R29W, Sec. 32, Meade County, Kansas. The strata in which the specimen occurred lie unconformably upon the Upper Pliocene Rexroad formation. (Plate II.)

DIAGNOSIS.—A very large species of *Terrapene* with proportionally elongate vertebrals, proportionally broad costals and very high marginals, the latter being approximately one-third of the height of the carapace. The twelfth marginal is almost as large as the preceding ones. The carapace has a very slight carina, flat vertebrals, and no lateral keel. The length of the femoral scute is one-half the length of the abdominal and one-third the length of the anal scute.

DESCRIPTION OF THE HOLOTYPE.—The shell is broad with slight elongation. The lateral costals give the appearance of overhanging the peripherals at the bridge. This is partly but not altogether due to distortion. The contour of the posterior peripherals is almost semicircular. The greatest width of the carapace is 162 mm. At the hinge the inside width is 127 mm. The length of the specimen from the anterior edge of the second vertebral scute to the posterior peripheral is 167 mm. Compared with the proportions of a large adult of *Terrapene carolina*, the total length of the specimen must have been about 232 mm.

The highest point of the carapace is at the anterior end of vertebral scute No. 2, which is

103 mm. high. From this point the carapace slopes gently posteriorly. The carapace is flat on top (Fig. 1A). This flatness is principally the character of the vertebrals and includes the proximal part of the costals. There is a slight carina, which extends throughout the length with the exception of the fifth vertebral. This slight elevation is continuous from vertebral No. 2 to No. 3. It is interrupted and barely visible on vertebral No. 4. Lateral to this carina there is a slight depression or trough.

The surface of the carapace has very fine reticulate ornamentation. The thickness of the

enlarged twelfth marginal is not found in any other recent or fossil form. The eleventh marginal is pointed and projects between the fourth costal and the fifth vertebral (Fig. 1A-B). The ninth marginal does not project between the third and the fourth costal scutes. The other marginals are approximately equal in size.

The fourth costal scute, on both the right and the left sides, presents a concave excavation which is continuous across the posterior part of the fourth vertebral, making a trough. The

TABLE I
MEASUREMENTS OF SCUTES OF HOLOTYPE,
Terrapene llanensis, UMMP 26957
Dimensions in Millimeters

Marginal			Costal			Vertebral		
Number	Length	Width	Number	Length	Width	Number	Length	Width
12	23	29	2	97	61	2	46	54
11	30	29	3	83	50	3	51	60
10	32	30	4	44	48	4	54	58
9	28	30	-	-	-	5	44	51
8	40	30	-	-	-	-	-	-
7	41	30	-	-	-	-	-	-

carapace is variable but averages about 5 mm. The sutures are entirely obliterated.

The vertebral scutes are narrower in proportion to their length than in Recent forms. The costal scutes are shorter in proportion to their width than in Recent forms. The vertebrals are fairly consistent in width with the exception of the fifth which is narrow. The fourth costal is almost square (Table I).

The marginal scutes flare slightly and are unusually high. They are approximately one-third of the height of the carapace. Peripherals Nos. 5, 6, and 7 are perpendicular and thus do not form a right angle as in *T. canaliculata*. The twelfth marginal is very wide and very high (Fig. 1A) and its width is equal to that of the other marginals. Its height is just slightly less than that of the other marginals. This

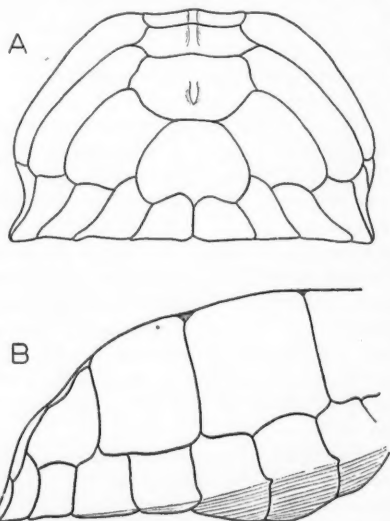


Fig. 1. *Terrapene llanensis* Oelrich, sp. nov. A—Posterior view of carapace. Holotype No. 26957, Museum of Paleontology, University of Michigan. B—Lateral view of carapace of same specimen.

fifth vertebral is dome-shaped, due to the attachment of the pelvic girdle within the carapace. This doming is found in all Recent forms, but is not so pronounced.

The internal part of the carapace does not differ from that of other members of the *Terrapene carolina* group. The flatness of the dorsal surface is reflected internally along the vertebral line. The marginals are very thick and heavy. Their ventral border extends horizontally. The impressions which receive the heads of the ilia are not as deeply excavated as in Recent forms.

The plastron is very slightly pointed posteriorly. There is a slight excavation of the

periphery at the junction of the femoral and anal scutes. The femoral scute flares slightly outward, although it is not appreciably wider than the abdominal.

The plastron is 150 mm. long at the mid-line and 142 mm. wide at the hinge. The abdominal scute is 48 mm. long, the femoral 23, and the anal 68. The femoral is approximately one-half the length of the abdominal and one-third the length of the anal scute. The lateral hinges are 46 mm. long or approximately one-third of the total length. The average thickness of the plastron is 10 mm. The hinge line is divided into two parts. The dorsal is horizontal and presents a rough suture line; the ventral, lobate on each half, is a smooth rounded shelf-like projection. The ventral surface is convex.

Of the appendicular skeleton the left femur is nearly complete. Its total length is 57 mm. Its distal end is 12 mm. wide. The general proportions are the same as those in Recent species of boxturtle. The femur is not as greatly curved anteroposteriorly as in Recent specimens.

The right tibia is 38 mm. long and greatly curved toward the mid line. The pelvis is fragmentary, but is not unlike that of Recent forms with a well-developed, low, depressed carapace.

DISCUSSION.—This boxturtle is closely related to the living *Terrapene carolina* group. Its relationships to the existing *Terrapene ornata* of the midwestern High Plains area are very remote.

Measurements show that the vertebral scutes of *Terrapene llanensis* are proportionately longer as compared to their width than in any of the Recent forms. The width-length ratio of the costals indicates that they are shorter in this form than in any of the Recent species.

No individual turtle can be assigned without question to a previously described species on the basis of its proportions. This is especially true of the boxturtle. In the specimen described here, however, the sutures are obliterated and the only distinguishing characters are the proportional measurements of the scutes. It is significant that the width-length ratios of both the vertebral and the costal scutes lie outside the observed ratios of Recent species.

The narrowness of the vertebral series as a whole is most similar to that of *Terrapene major*, and the proportions of the costals also resemble those of that form. Although these

measurements closely approximate those of *T. major*, they do not overlap them.

As has been previously noted, there is a group of large fossil boxturtles that has been considered ancestral to *T. major* and that was placed in synonymy with *T. canaliculata* by Barbour and Stetson (1931). *Terrapene llanensis* resembles closely the type of *T. canaliculata* (Hay). Three nearly complete specimens of *T. canaliculata* (USNM 11834, 11428, and 12000) were used for comparison as well as the type specimen (USNM 5500) and many other fragmentary specimens. *T. llanensis* differs from *T. canaliculata* in the absence of both a well defined dorsal carina and a well developed lateral keel. The fourth vertebral scute in *T. llanensis* is much shorter than in *T. canaliculata* with the result that the twelfth marginal is very large. In some specimens of *T. canaliculata* the twelfth marginal reaches half the height of the other marginals, but in none is it as large as in *T. llanensis*.

In *T. llanensis* only the eleventh marginal projects between the distal ends of the costal scutes, however, whereas in *T. canaliculata* the marginals No. 5, 7, 9, and 11 project high between the costal scutes. The peripheral bones No. 5, 6, and 7 of *T. llanensis* are perpendicular, while the corresponding bones of *T. canaliculata* are rolled beneath the carapace and in cross section form a right angle.

The vertebrals of *T. canaliculata* are flat on top. This flatness does not include part of the proximal end of the costals as in *T. llanensis*. The width-length ratios of the vertebrals are less in *T. canaliculata*; or in other words, the vertebral series of *T. llanensis* is broader. Correspondingly, the width-length ratios of the costals are less and the costals shorter in *T. llanensis*. The external measurements of the plastron are the same, although in *T. canaliculata* the length of the abdominal scute is more than twice the length of the femoral scute.

In describing *T. llanensis* an attempt has been made to show its affinities to both the Recent and fossil forms. It has been noted above that *T. llanensis* resembles the Recent *T. major* and that *T. canaliculata* is considered to be the ancestor of *T. major*. Of the known fossil forms *T. canaliculata* is the closest relative. Both *T. canaliculata* and the Recent *T. major* are more highly specialized in their structure

than the High Plains form. They both possess a well developed dorsal carina, a well developed lateral keel, elongate vertebrals, and a generally elongate streamlined body. The position of *T. canaliculata* as ancestor of *T. major* would, therefore, seem reasonable. The resemblances of *T. llanensis* and *T. canaliculata* indicate a relationship between them comparable to that of the living forms of boxturtles throughout the eastern United States and México.

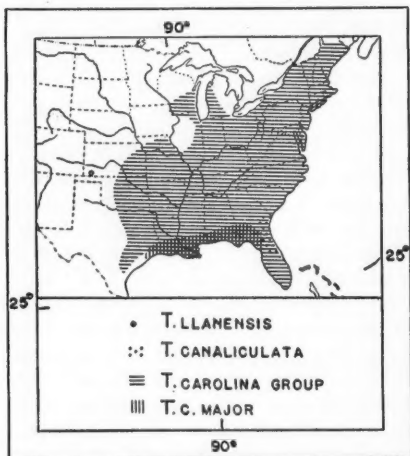


Fig. 2. Localities of Pleistocene specimens and approximate distribution of extant forms of the *Terrapene carolina* group.

The Recent forms of the *Terrapene carolina* group (Fig. 2) occupy a temperate woodland habitat which may vary as to humidity. This habitat is significant of the climate indicated by the presence of *T. llanensis* in southwestern Kansas during the middle or late Pleistocene. The *Terrapene carolina* group in the United States includes the living *T. c. major*, *T. c. carolina*, *T. c. triunguis*, and *T. c. bauri*.

Terrapene canaliculata has been found only in the southern part of Georgia and Florida. The presence of *T. llanensis* in southwestern Kansas extends the distribution of the mid-Pleistocene boxturtles to the northwest. This distribution is greater than that of its closest living relative, *T. major*, which is restricted to the Gulf coastal plain (Florida and Texas), and greater than the present distribution of the *Terrapene carolina* group (Fig. 2). This northwestern extension of the *Terrapene carolina* group indicates an interglacial climate in Kansas during the middle or late Pleistocene.

ASSOCIATED FORMS.—*Tremarctotherium simum* (Cope), short-faced bear; *Mammuthus columbi* (Falconer), Columbian elephant; *Paramylodon*, a large sloth; and various invertebrates occurred with the turtle and were reported by Rinker (1949).

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A New Cave Species of Salamander of the Genus *Hydromantes* from California, with Notes on Habits and Habitat

JOE GORMAN AND C. L. CAMP

OVER forty years ago a batch of salamanders was collected by Eustace L. Furlong in a cave in the Triassic limestones above Squaw Creek in Shasta County, California. Mr. Furlong picked the specimens from the moist walls of a small dark grotto near the entrance of a cave situated on the northwest slope of Brock Mountain, near the head of Bars Creek or Dinner Gulch. Subsequent search of that area by Camp in 1924, and again by Camp and Gorman in 1950 and 1951, failed to locate Furlong's salamander cave. The specimens he collected (now missing) were examined by Camp in 1915 and identified as an unknown species of *Spelerpes*. They were not described because of their mummified condition.

On June 12-13, 1950, Gorman discovered a colony of Furlong's salamanders along the Flat Creek Road running east from Squaw Creek and four miles north of Shasta Reservoir (Fig. 1A). We revisited this site on October 13-14, 1950 and collected more specimens, and again on June 10-11, 1951 but found none. Search of many promising sites in the vicinity produced only one other individual, at Madison Creek just below a road culvert. On March 10-11, 1951, Gorman found a colony on the east bank of the McCloud River near Stoneman, Baird, and Potter Creek caves (Fig. 1B), and finally on June 10, 1951, we obtained specimens from small caves near the summit of Brock Mountain, confirming Mr. Furlong's account and probably not far from his locality (Fig. 1C).

The following description is based upon specimens from the Flat Creek Road locality on Low Pass Creek. (The name of Low Pass Creek is misplaced on U. S. G. S. Bollobokka quadrangle, ed. 1948.)

Hydromantes shastae, sp. nov.

TYPE.—Museum Vertebrate Zoology (MVZ) No. 52314, adult female, collected June 12, 1950, under a small mossy log at the entrance to limestone caves at the edge of Flat Creek Road in the narrows of Low Pass Creek (0.7 mi. east of Squaw Creek Road, 18.4 mi. north and 15.3 mi. east of Redding), Shasta County, California. Elevation 1500 ft. (Fig. 1A).

PARATYPE.—MVZ 52318, adult male, collected October 13, 1950, about 35 m. east of the type, in humus under a large rock.

DIAGNOSIS.—A plethodontid salamander with pedunculate tongue, blunt toes with webs extending more than halfway to tips, and a blunt tail; readily distinguishable from all California salamanders except *Hydromantes platycephalus*. It differs from *H. platycephalus* (Camp, 1916) in its larger more protrusive eyes, narrower head and prominent supranasal ridge (canthus rostralis), more cylindrical body, and blunter toes.

DESCRIPTION OF TYPE (based on the live animal).—Head slightly flattened, indistinctly set off from neck; body subcylindrical, slightly depressed; costal grooves prominent; tail one-third of total length, broad at base, cylindrical, blunt; vertebrae evident under skin. Dorsal ground color reddish chocolate, mottled with melanophores and chromophores (the non-melanin chromatophores) in aggregations varying in size from specks and patches to solid shields of color especially over the top of the head, the snout, the eyelids, and the tail (much of which shows but few melanophores). Mahogany (Maerz and Paul, 1930, pl. 7, row J, line 10) on back of head, Sudan Brown (14, L, 12) or Chipmunk (13, L, 9) on tail, Java + (8, H, 10) most prominent on back, Sorrel (13, J, 11) on upper surface of hind legs; belly brown-cream (greyish) approximating Leaf Mold (8, L, 11), varying in density with thickness of skin and reflections from viscera; sides with flecks and lichen-like patches; silvery (guanine-like) in tone sprinkling throat and crossing pectoral and pelvic regions ventrally; similar silvery patches powder the limbs (Table I).

COMPARISONS.—External characters establishing the generic identity of *H. shastae* with *H. platycephalus* are the extensively protrusible tongue with tip a circular disk free all around, palatal tooth patches well separated, premaxillary teeth enlarged in adult males, toes strongly webbed, palmar tubercles lacking, and tail subcylindrical and blunt tipped.

Hydromantes shastae differs from *H. platycephalus* as follows: body less flattened; head

narrower, less flattened and with distinct supranasal ridge; head in male not much wider than in female; mental gland of male more highly developed; eyes larger and more prominent; nostril-orbit length shorter (Fig. 2; Fig. 3A, D); premaxillary teeth in male not so elongate (in 6 animals); vomerine teeth rows more curved

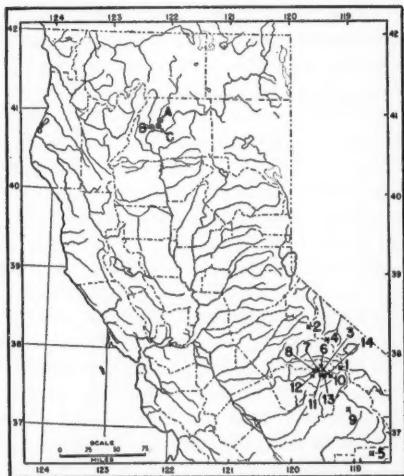


Fig. 1. Locality records for *Hydromantes* in California. Letters (*H. shastae*) and figures (*H. platycephalus*) are in order of discovery; localities 1, 3, 6-7, 10-14 are in Yosemite National Park. *Shasta Co.*: A, Low Pass Creek, 1500' elev.; B, McCloud River (Baird and Potter Creeks), 1100'; C, Brock Mountain, 2550'. *Calaveras Co.*: 2, Sonora Pass (Chipmunk Flat), 9500'. *Mono Co.*: 4, Peeler Lake, 9500'. *Mariposa Co.*: 7, Tenaya Canyon, 5300'; 6, Cloud's Rest, 9929'; 8, base of upper Yosemite Falls, 5140'; 3, Half Dome, 8850'; 12, Cathedral Rocks, 5100'; 13, Vernal Falls (above Mist Trail), 5025'; 14, upper trail to Nevada Falls, 5400'; 11, Ledge Trail (including Firefall Ledge), 6600'. *Tuolumne Co.*: 1, head of Lyell Canyon, 10800'. *Madera Co.*: 10, meadow near Triple Divide Peak, 10700'. *Fresno Co.*: 9, Bald Mountain, 7834'. *Tulare Co.*: 5, Silliman Gap, Sequoia National Park, 10000'.

and teeth less numerous (9-14 on each side in *H. shastae*, 6 individuals; 13-18 in *H. platycephalus*, 8 individuals), and not meeting in midline in females; parasphenoid teeth patches longer and more convergent anteriorly (the space between, in *H. shastae*, is less than three-fourths of the patch width); tail relatively longer, slightly broader at base; limbs heavier and longer, adpressed they overlap by one or two costal folds in adults, two and a half to

three folds in juveniles (rarely as much as one fold in live *H. platycephalus*); toes blunter and more truncate at tips, less widened at joints; webbing more extensive, often extending to middle of second phalanx (Fig. 3 B, C, E, F).

Color differences between the two species are evident. In the Shasta form the reddish-chocolate ground color contrasts strongly with the darker Sepia (8, A, 2; 8, A, 9-10) of *H. platycephalus* from Vernal Falls and Half Dome in the Yosemite. The Yosemite species has a more mottled melanophoric pattern. The usual reddish colors of *H. shastae* contrast with the greenish-gold cast which is less pronounced in the high Sierran forms than in those from Vernal Falls.

The color differences between the two Californian species seem to be repeated approximately in the mainland Italian and Sardinian forms as observed by Robert Mertens (quoted in Dunn, 1923, p. 350): "in opposition to the numerous mainland specimens ... these cave salamanders looked very different; among other things I was struck by the entire lack of brown or red-brown tones in these Sardinians; their coloration gave an olive-green impression."

Other color differences between the Californian forms include the larger patches of silvery grey pigment (in *H. shastae*, 37, B, 1-3; guanistic chromophores?) on the sides of the belly and beneath the girdles of *H. shastae*, and the more solid coloration of the tail.

There appear to be noteworthy divergences in behavior, probably correlated with the remarkable habitat differences of the two species. *Hydromantes shastae* is more sluggish than the Yosemite form. Optimum temperatures for the two forms evidently differ. Temperatures as low as 3-4° C seem to cause no significant decrease of activity in the high mountain form. In *H. shastae* such temperatures produced a torpor which persisted for 20 to 30 minutes in the young and for 40 to 50 minutes in the adults after removal to room temperatures (22-24° C). Conversely, temperatures of from 15 to 18° C did not seem to affect the Shasta form but caused noticeable reduction of activity in the Vernal Falls animals.

The feeding habits of the two species in captivity are similar. Flies introduced into the vivarium are taken at distances of from 4 to 6 cm. from the mouth. The salamanders carefully

Specimen
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174 ♀

187 ♂

188 ♂

198 ♂

267 ♂

268 ♂

269 ♂

275 ♀

276 ♂

277 ♀

278 ♂

301 ♀

257 ♀

258 ♂

261 ♀

320 ♂

321 ♂

322 ♂

323 ♀

324 ♂

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TABLE I
CHARACTERISTICS OF ADULT *Hydromantes shastae*

Specimen numbers are those of Gorman's catalog, not all have been entered in MVZ catalog; however, G174 = MVZ 52314, G187 = MVZ 52318. Limb overlap in terms of costal grooves. Color of head, back, tail are chromophore colors; base (or ground) color, melanophores (Maerz and Paul, 1930). The measurements (in mm.) were taken from living specimens anaesthetized with chlorotone.

Specimen number and sex	Total length	Head length	Head width	Interorbit width	Nostril-eye	Eye length	Depth of maxilla	Front leg	Hind leg	Axilla-groin	Snout-gular fold	Gular fold-vent	Snout-vent	Tail	Limb overlap	Head color	Back color	Tail color	Base color
Low Pass Creek																			
174 ♀	89.6	10.2	9.4	2.5	2.2	4.2	...	15.9	16.4	...	14.3	45.2	59.5	30.1	1.5	7J10	8H10	14L12	8L11
187 ♂	96.2	11.4	10.2	3.6	3.4	4.5	...	18.8	20.3	...	15.5	47.7	63.2	34.5	1.5	7L6	7L6	6L12	8E5
188 ♂	88.0	11.0	9.0	3.2	2.7	3.7	...	...	...	...	...	44.9	...	30.2	2	...	...	...	...
198 ♂	83.4	10.1	9.5	2.9	2.8	3.7	...	...	...	...	...	40.3	...	30.1	...	...	...	...	...
267 ♂	75.5	9.6	9.1	2.4	2.0	3.4	2.8	15.7	16.5	25.4	12.9	37.2	50.1	25.1	2	15L11	15J7	14J8	8C2
268 ♂	83.7	11.0	10.0	2.6	2.2	4.2	3.1	16.1	17.1	...	13.1	41.2	54.3	29.9	2	14H7	14J7	13K7	8E8
269 ♂	92.2	11.0	10.1	2.8	2.1	4.0	3.1	17.2	19.3	...	14.2	47.8	60.0	32.8	2	8J11	14J8	13L9	8E8
275 ♀	83.0	10.3	9.5	3.1	2.0	3.9	...	16.0	17.5	27.1	13.2	41.4	54.6	27.7	1.5	...	...	...	...
276 ♂	90.3	10.6	9.6	2.5	2.8	3.9	3.2	16.0	18.3	...	14.3	46.4	57.7	31.9	2+	8L12	8E11	7A11	8E3
277 ♀	100.2	11.2	11.0	3.0	2.8	4.8	2.8	18.0	20.8	30.5	15.5	46.7	62.2	36.3	2.5	8H11	7C11	6F12	8C3
278 ♂	91.5	10.9	9.7	2.4	2.4	4.1	3.1	16.8	18.8	31.2	14.3	44.4	58.7	32.3	2	8L12	8E10	6A12	8E3
301 ♀	91.1	9.8	10.1	3.5	2.0	4.7	...	14.0	17.8	...	15.5	...	...	...	...	...	...	...	...
McCloud River																			
257 ♀	82.8	11.2	9.8	3.1	2.8	4.6	2.8	16.0	17.0	...	14.2	42.7	56.9	27.5	1.5	14G10	16J12	13K5	7E2
258 ♂	78.8	10.1	9.6	3.0	2.3	3.8	2.7	13.6	15.2	...	13.6	39.8	53.4	24.6	1.5	13L7	14C6	13L5	8D5
261 ♀	87.3	11.0	9.7	3.3	2.7	4.5	2.9	15.8	17.9	...	15.4	48.2	63.6	26.7	1-	15E10	15L8	13K8	8D3
Brock Mountain																			
320 ♂	91.7	12.6	9.9	2.8	3.0	3.9	2.4	17.6	18.4	28.1	14.4	45.3	59.7	32.7	2+	15H12	15L10	13L7	8E3
321 ♂	89.7	11.5	10.3	2.6	3.6	4.1	2.4	15.4	17.3	30.7	14.7	46.5	61.2	29.1	1.5+	14J12	14D6	13K6	7L12
322 ♂	86.8	11.0	10.1	3.0	2.8	4.2	2.5	15.3	18.1	29.9	13.7	45.0	58.7	29.1	1.5	14K9	14L7	13L6	7H3
323 ♀	81.7	10.6	10.2	2.8	3.0	4.4	2.4	16.2	18.0	31.5	14.8	46.8	61.6	...	...	7K12	7J10	4H10	7E2
324 ♂	79.3	10.4	9.1	2.8	2.7	3.7	2.6	16.3	17.7	26.1	13.2	40.6	53.8	26.3	2	15H12	15J6	14L9	7H2
325 (?)	69.0	9.3	8.0	2.3	1.8	3.2	2.1	12.5	13.7	24.2	10.8	35.7	46.5	23.1	1.5	...	...	...	...

judge the distance, sometimes elevating or extending the body so that the front feet, chameleon-like, are raised above the substrate. They shoot out the tongue in a quick darting stroke, catching the insect as the tongue lashes

downward, and then pull it back so rapidly that the eye can scarcely follow the movement.

The blunt tip of the tail is used as an aid in walking and climbing by *H. shastae* in the peculiar way described by Stebbins (1947) for

H. platycephalus and by Taylor and Smith (1945) for *Bolitoglossa cephalica* and *B. galeanae*.

HABITAT.—*Hydromantes shastae* occurs in limestone caves, fissures and crevices, and in damp weather in limey soil and humus under stones and litter in the immediate vicinity of such caves and crevices. Evidently it forages abroad only at night and retreats into the caverns and fissures during the dry season

penetrated by caves and crevices and a constant stream of water issues from a spring in a small cave at the base. This is the only permanent water in the vicinity. The upper caves are dry as far down as they can be entered (15 m.). The salamanders live in the shadiest part of the ravine adjacent to the fissured limestone and within the fissures, confining themselves to the base of the south wall of the gorge where the rocks are blanketed with moss under a luxuriant stand of Douglas spruce (*Pseudotsuga taxifolia*), black oak (*Quercus kellogi*), wild currant (*Ribes*), thimbleberry and maidenhair fern. Wild grape, alder, and Oregon maple (*Acer macrophyllum*) line the stream bed which is dry immediately below the salamander colony and which receives the spring 100 m. below.

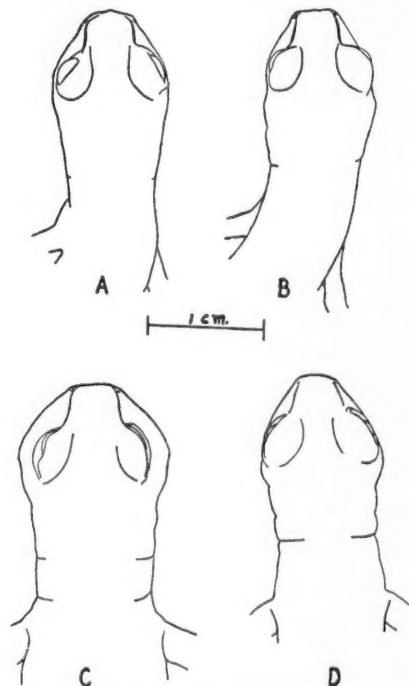


Fig. 2. Comparative head widths of *Hydromantes shastae*: A, ♂, MVZ 52318; B, ♀, MVZ 52314 (from life). *H. platycephalus*: C, ♂, CAS 55522; D, ♀, MVZ 26179 (from preserved specimens).

(July–October). In this it seems to resemble *H. italicus* as reported by Lanza (1946) on the Riviera. In the drier parts of its range, as on the upper slopes of Brock Mountain, it is probable that *H. shastae* rarely ventures out from the caves. These slopes are intensely hot and dry in the summer, but the caves are moist and cool.

At the type locality of *H. shastae* the habitat is in a shady gorge where a ravine (Low Pass Creek) cuts through a karst of gray limestone. The south wall of the gorge is a vertical cliff,

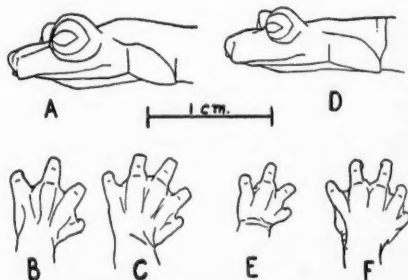


Fig. 3. Head, forefoot and hindfoot of *Hydromantes shastae*: A, MVZ 52314; B and C, MVZ 52318, ♂. *H. platycephalus*: D, MVZ 52112; E and F, MVZ 26179, ♀.

The opposite, south-facing slope and cliff support a thin stand of Digger pine (*Pinus sabiniana*) and buckeye (*Aesculus californica*) characteristic of the Upper Sonoran Zone.

On October 13–14, 1950, six or seven days after a light rain had penetrated 5–7 cm. into the dry soil, the stream and the caves were dry; nevertheless a few *Hydromantes* were found beneath large rocks and a log in the shadiest part of the gorge adjacent to the limestone fissures. The presence of salamanders under the same rocks on two successive days indicated that they had been foraging in the open at night, although none was disclosed during a flashlight search. *Hydromantes* was not found elsewhere even after prolonged search, except for one individual at Madison Creek (16.1 mi. N, 14.0 mi. E of Redding). The soil at points of capture was a loose, damp, red, decomposed limestone with humus. The life-zone

is the lowermost Transition including the boundary between Transition and Upper Sonoran. Yellow pines occur sparsely about 1200 ft. above on the northwest side of Devil's Peak and Digger pines grow on the higher summits and generally on the south-facing slopes.

Hydromantes shastae lives in the coolest, shadiest part of this dry ravine but not in the coolest and shadiest parts of the adjacent forest. Even at this low elevation (1500 ft.) there are moister and more densely wooded areas where the aquatic larvae of *Dicamptodon ensatus* live in cold streams under the broad spreading leaves of the giant saxifrage, *Peltiphyllum peltatum*. Adults of *Dicamptodon* hide during the day in moist leaf mold under fallen logs on north-facing slopes. The streams are inhabited by newts (*Triturus sierrae*) during the breeding season (closing June 12–13, 1950). The speckled black salamander, *Aneides flavipunctatus*, is common along the banks of the cooler streams where it hides in the daytime under rocks at or near the stream margins. At the road crossing of Madison Creek (1300 ft.) one *Hydromantes* was found in the habitat of *A. flavipunctatus* under a rock at the streamside. There were limestone fissures nearby in a north-facing mossy bank.

The habitat of the population recently discovered (March 19–11, 1951) along the eastern shores of the McCloud River arm of the Shasta Reservoir differs from the Low Pass and Madison Creeks localities. Four specimens were taken on the south-facing limestone talus slopes below Baird and Stoneman caves (13.7 mi. N, 5.9 mi. E of Redding; 3 specimens from 1300 ft. to 2300 ft.) and below Potter Cave (13.4 mi. N, 6.0 mi. E of Redding; 1 specimen, 1150 ft.). The life-zone was definitely Upper Sonoran, and the animals were found under large limestone slabs on decomposed damp-to-wet limestone soil (one in humus).

The Brock Mountain caves lie at an elevation 1000 ft. above the Low Pass Creek locality and are in a warm and dry summer climate, similar to the McCloud River area.

Only one other salamander, *Ensatina eschscholtzi platensis*, another plethodontid, is known to occur within the ranges of both Californian species of *Hydromantes*. On the Vernal Falls Mist Trail in Yosemite Valley three *Ensatina* were taken within 0.2 mi. of the habitat of *H. platycephalus*, under rocks in dark, damp humus of pine and oak litter. The *Ensatina* niches are similar in the foothills of Mt. Shasta, and *Hydromantes* has been taken, in the type locality, under rocks alternating with those under which *Ensatina* has been found. The species of *Hydromantes* range farther up through the life zones than does *Ensatina*.

We wish to express our appreciation to Dr. Robert C. Stebbins, and to Miss Joan Sischo for a careful rendering of the drawings.

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A New Subspecies of the Snake *Coluber constrictor* from Florida

WALTER AUFFENBERG AND LEWIS HALL BABBITT

DURING the course of several collecting trips to southern peninsular Florida it became apparent that the population of *Coluber constrictor* inhabiting the Everglades warrants subspecific recognition. The relationships of this new form with the other subspecies will be discussed in a later paper.

The first reference to this form seems to be by Conant (1930). While collecting in southern Florida, he observed five specimens of *Coluber constrictor* that were very much similar to *C. c. flaviventris* in coloration. Apparently, the only other mention of the southern Florida race was by Carr (1940) who remarked that specimens from the Eastern Rock Rim and the Cape Sable region were very light in color. Up to the present time the description of this form was inadvisable due to the paucity of material. Collections made chiefly by the junior author in recent years considerably rectified this situation. The new form may be known as

Coluber constrictor paludicola, subsp. nov.

Everglades racer

HOLOTYPE.—USNM 131,900, collected March 23, 1950 by L. H. Babbitt, three miles west of Kendall, Dade County, Florida.

DIAGNOSIS.—A subspecies distinguished from *C. c. constrictor* and *priapus* by its considerably lighter dorsal and ventral coloration, and from *C. c. flaviventris*, *mormon* and *stejnegerianus* by its higher number of subcaudal scales, a lesser number of dorsal saddles, and a reddish cast to the general body colors when young. It differs from *C. c. anthicus* by its unspotted dorsal surface in the adult. The young of *anthicus* seem unknown.

DESCRIPTION OF THE HOLOTYPE.—A mature male; body length 786 mm., tail length 294 mm. Scale rows 17–17–15, with the reduction taking place opposite the 112th ventral plate. The supralabials are 7–7; infralabials 8–9; temporals 2–2–2; preoculars 2–2; postoculars 2–2; and the gulars 5–5. The first supralabial on each side is in contact with the loreal. The ventrals are 182, subcaudals 111, and the anal is divided.

Color in life greenish gray dorsally, lightest

on the neck, slightly brownish gray posteriorly, gray laterally; interstitial skin gray dorsally, black laterally; chin and throat white, with a yellowish bloom; belly bluish gray with powder blue clouding, gray on the lateral edges; top of the head bluish gray; supralabials anteriorly brown, third and fourth mostly white, posterior ones mostly bluish brown above and white below; tongue pink at base, black for its greater length, and dark brown at tips; pupil of the eye black, iris orange-gold with a red crescent above.

PARATYPES.—The paratypes, all from Dade County, are as follows: University of Michigan Museum of Zoology No. 104067, 1 mile north of Kendall. Chicago Natural History Museum No. 66561 and American Museum of Natural History No. 71620, 3 miles southwest of Miami. Personal collection of Walter Auffenberg No. 3640, 3 miles west of Kendall (paratopotype); No. 3639, 6 miles west of Miami; No. 2440, Crandon Park, Biscayne Key; No. 3638, Miami; No. 3615, 10 miles south of Florida City; No. 3625, Homestead. Carnegie Museum No. 29736, Perrine. University of Florida Department of Zoology No. 606, Miami. United States National Museum No. 85304, Paradise Key; No. 85305, Miami; Nos. 28912, 30941 and 32091, Lemon City.

VARIATION.—Thirty-six specimens of this form were examined. The following summary of variations includes the paratypes as well as the additional specimens.

The first supralabial is in contact with the loreal scale in all specimens except one, where it is separated from the loreal by the postnasal. The supralabials usually number 7, but are 8 in one specimen. The normal infralabial count is 8, with counts being distributed as follows: 8(29), 9(4) and 10(3); average, 8.4. The gulars range from 3 to 5 and average 4.1. The temporals are quite variable, usually being arranged in three series. The most common condition is 2–2–2, which is typical of the species *constrictor*. The dorsal scale formula is 17–17–15 in all specimens, and the reduction occurs from the 102th to 150th ventral plate. The mean is 113.3. The ventrals range from 177 to 191, with a mean of 184.6. The subcaudals range from 99 to 117, with a mean of 107.2. The total length divided

by the tail length varies from 3.2 to 3.8. Sexual dimorphism, if it exists, is very slight.

The hemipenial spine is always 4 times the length of its predecessor, similar to the condition in *priapus*.

The dorsal coloration is normally a bluish gray, but in occasional specimens it may be greenish brown or greenish gray. The top of the head is most commonly olive gray. Brownish specimens are usually so colored only before the skin is shed; after sloughing, the skin shows the normal grayish coloration. In formalin these colors darken considerably. Ventrally the ground color varies from yellowish white to white. The markings are cloudy blotches which range from powder blue to grayish brown, and in some individuals may be so placed along the lateral edges of the ventral plates that a faint, light, midventral line results by contrast. The posterior gulars and lateral scales of the anterior part of the neck are usually tinged with brown. Small black punctations may be scattered over the ventral surface as is common in some specimens of *C. c. priapus* and in occasional specimens of *flaviventris* from the southern portions of its range.

RANGE.—The Everglades from the extreme southwestern region of Cape Sable throughout the southern tip of the Florida peninsula, westward to the eastern borders of the Big Cypress Swamp, northward to the southeastern portion of the Okaloacoochee Slough, eastward to central Palm Beach County, and southward throughout most of Broward County except the most eastern portion along the coast known as the Eastern Pine Belt. It intergrades with *C. c. priapus* on both Lower and Upper Matecumbe

Key, Monroe County, and presumably all around the edges of the Everglades.

Intergrades have been examined from the following mainland localities: Collier County—10 miles north of Immokalee, 6 and 8 miles east of Immokalee, and Ochopee. Hendry County—16 and 20 miles south of Clewiston. Broward County—Fort Lauderdale, and Hallandale.

ADDENDA.—After submitting this paper for publication, Bell (Herpetologica, 1952, 8(2): 21) described a new subspecies, *C. c. haasti*, from the Lower Keys of Florida. Of the five characters that are stated as being diagnostic of the new race, none is restricted to it, either being always found in *priapus*, or being found spasmodically in both. Two of the characters are extremely difficult to evaluate. Furthermore, there is considerable overlap and the differences in such characteristics as "luster," if valid at all, are too slight to warrant the erection of a new race based on these characters alone. The data supporting these reasons for relegating *haasti* to the synonymy of *C. c. priapus* will be given in a forthcoming paper by the senior author, which will discuss the variations and relationships of all of the eastern races of this species.

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The Modification by Temperature of the Photoperiodic Control of Gonadal Development in the Lizard *Xantusia vigilis*

GEORGE A. BARTHOLOMEW, JR.

KNOWLEDGE of the role of environmental factors in the timing of reptilian reproduction is fragmentary and inconclusive. Nevertheless, some reptiles lend themselves readily to the kinds of investigation of this topic which have been extensively carried out on birds and mammals.

In a previous study (Bartholomew, 1950) it was shown that increased length of day is more important than increased temperature in accelerating the gonadal growth of *Xantusia vigilis*, a small ovoviviparous lizard found in the deserts of southwestern United States and northern Mexico. The present experiments

were undertaken to investigate the interactions between day length and temperature in the gonadal cycle of this animal.

As in the previous experiments, the lizards were taken from the population inhabiting an area 10 miles southeast of Palmdale, Los

TABLE I
CONDITIONS OF LIGHT AND TEMPERATURE IN THE
50-DAY EXPERIMENT

Group	Light intensity in foot-candles: mean and range	Hours of light per day	Temperature in degrees Centigrade
1	62 (60-64)	16	8
2	64 (61-67)	16	20
3	61 (58-64)	16	32

animals per bowl. Although the sex of the lizards could not be determined until the animals were dissected at the end of the experiment, it developed that each finger bowl contained several representatives of each sex.

For 50 days starting January 1, 1950, each of the three groups was maintained under similar light regimes, but under different conditions of temperature (Table I). The light for each group was supplied by "daylight" fluorescent lamps which were controlled by an electric timing switch. Groups 1 and 3 were kept in insulated chambers in which the temperature was controlled to within 1°. Group 2 was kept in an inside room in which the temperature remained constant to within 2°.

On the fifty-first day the lizards were weighed and measured. Their gonads were removed and weighed, and the testes were fixed for histological examination.

TABLE II
THE EFFECTS OF TEMPERATURE ON THE BODY WEIGHT AND ON THE COMBINED WEIGHT OF BOTH GONADS
OF *Xantusia* KEPT ON 16 HOURS OF LIGHT PER DAY FOR 50 DAYS

Temperature	Mean change in body weight per lizard	Males		Females	
		Number	Mean weight of testes at end of experiment	Number	Mean weight of ovaries at end of experiment
8°C.	-0.1 g.	27	10.6 ± 3.7 mg	26	5.8 ± 3.0 mg.
20°C.	+0.1 g.	25	17.7 ± 12.4 mg	30	6.8 ± 3.5 mg.
32°C.	+0.3 g.	25	5.7 ± 4.3 mg	31	5.9 ± 4.2 mg.

Angeles County, California. The techniques of capture and maintenance used in the present investigation were the same as those described in the paper referred to above, except that drinking water was available at all times. All the experimental animals had snout-vent lengths greater than 35 mm. which, according to Miller (1951), indicates that they were at least in their third year. All temperature references are in degrees Centigrade.

THE EFFECTS OF 8, 20 AND 32° FOR 7 WEEKS DURING WINTER

On December 11 and 12, 1949, 185 *Xantusia* were captured and placed in a darkened, controlled temperature chamber at 10-12°, and kept there until December 31 when they were segregated into three groups matched in size. The members of each group were weighed and placed in seven-inch finger bowls, 11 or 12

RESULTS.—At each of the three temperatures the lizards behaved differently. At 8° they were almost completely torpid and, although food was available at all times, they did not eat. At 20° they were active and fed normally. At 32° they fed more heavily and were extremely active. The change in weight per lizard at each temperature during the experiment was marked (Table II). There was no significant difference in mortality between the three groups; in each it was slightly less than 4 percent.

The modification by the different temperatures of the effect of artificially lengthened days on gonadal weight was noted (Table II). In each group, the experimental conditions accelerated ovarian growth and produced ovaries larger than the seasonal norm given by Miller (1948) as 3.9 g. Ovarian weight showed no correlation with temperature. The differences between the means of the three groups are not

statistically significant. For example, the standard error of the difference between the mean ovarian weight of the animals kept at 8° and that of those maintained at 20° is only 1.07. These results confirm the previously reported finding that artificially increased day length causes a small amount of unseasonal ovarian growth in *Xantusia vigilis*, and in addition the results indicate that, during the winter and at temperatures between 8° and 32°, temperature has only a slight effect on the female's photoperiodic response.

The experiment was ended in the last week of February. Miller (1948) has reported that the mean weight of the testes of *Xantusia*

tween 8 and 32° (Table III). The photoperiodic response of the males is not completely inhibited even by temperatures as low as 8° C. At the end of February freshly captured males show nothing more advanced than spermatocytes (Bartholomew, 1950; Miller, 1948), while approximately a third of the males kept at 8° had testes which contained spermatids.

After 50 days all except one of the males kept at 32° had passed the peak of spermiogenic development and had either begun or already completed testicular regression. (Regressed testes were readily identified by the association of an epididymis containing spermatozoa with a testis containing involuted or involuting tubules.) Therefore, this experiment did not allow the examination of the testes of the lizards kept at 32°, until they had apparently passed their peak in size, and so it did not give data

TABLE III

THE EFFECT OF TEMPERATURE ON THE SPERMATOGONIC CONDITION IN *Xantusia* EXPOSED FOR 50 DAYS TO 16 HOURS OF LIGHT PER DAY

Spermatogenic condition	8°C.	20°C.	32°C.
Regression completed, but a few spermatozoa still in epididymis	—	—	8
Tubules beginning to regress	—	—	15
Tubules containing maximal number of spermatozoa	—	3	1
Many spermatids present, individual spermatozoa beginning to appear	—	12	—
Many spermatocytes and spermatids present	9	10	—
Only spermatogonia and spermatocytes present	20	—	—

vigilis captured at this time of year is about 8 mg. The testes of the experimental animals kept at 8° and at 20° exceeded this weight, while those of the animals kept at 32° did not (Table II). The mean weight of the testes of each group differs significantly from that of the others; the standard error of the difference between the mean testicular weight of the animals kept at 8° and that of those kept at 20° is 2.9, and that between the animals kept at 20° and the animals kept at 32° is 4.6.

The small size of the testes of the animals kept at 32° does not, however, indicate that this temperature inhibited the production of spermatozoa. The stimulating effect of artificially lengthened days on testicular development increases directly with temperature be-

TABLE IV

CONDITIONS OF LIGHT AND TEMPERATURE IN THE 21-DAY EXPERIMENT

Group	Light intensity in foot-candles: mean and range	Hours of light per day	Temperature in degrees Centigrade
1	79 (76-82)	16	20
2	80 (77-83)	16	32

on testicular weight which could be compared with those from the other groups; nor did it allow the determination of the interval required for the production of spermatozoa at 32°.

EFFECTS OF 20° AND 32° FOR THREE WEEKS IN THE FALL

To compare the effects of 20° and 32°, an experiment was required which would be of such duration that the males of neither group could pass the peak of either spermiogenic activity or testicular size. During the last week of November, 1950, 69 adults were captured in the area previously described and kept on normal day length at 20° until November 28, when they were weighed, placed in finger bowls (8 or 10 per bowl), and separated into two matched groups. These groups were then given the experimental treatment shown in

Table IV. Light was supplied by "daylight" fluorescent lamps, and temperature was maintained to within 1° by thermostatically controlled insulated chambers. On the twenty-second day the animals were measured and weighed; their gonads were removed and weighed, and the testes prepared for microscopic examination.

RESULTS.—During the experiment there was no mortality and the animals in each group showed the same mean increase in body weight per individual (0.1 g.). Gonadal growth was accelerated in both sexes at both temperatures (Table V).

The difference between the weight of the ovaries of the animals kept at 20° and that of the animals kept at 32° was not significant (standard error of the difference between the two means, 1.68). The magnitude of the ovarian response was as great after 21 days as

TABLE V

THE EFFECTS OF TEMPERATURE ON THE COMBINED WEIGHT OF BOTH GONADS OF *Xantusia* KEPT ON 16 HOURS OF LIGHT FOR 21 DAYS

Temperature	Males		Females	
	Number	Mean weight of testes at end of experiment	Number	Mean weight of ovaries at end of experiment
20°C.	14	14.1 ± 4.7 mg.	20	5.9 ± 2.3 mg.
32°C.	16	10.4 ± 7.1 mg.	19	5.0 ± 2.5 mg.

after 50 days. The standard error of the difference between the mean ovarian weight of the animals kept at 20° for 21 days and that of the animals kept at the same temperature for 50 days is 1.08, and for the animals kept at 32° the comparable statistic is 0.82.

As in the previous investigations of photoperiodism in this species, the response of the males was much more conspicuous than that of the females. Spermiogenic development was augmented more by a temperature of 32° than by a temperature of 20°. Five of the animals exposed to 32° progressed from the resting gonadal condition to full spermiogenic activity in the 21 days of the experiment, while none of the animals exposed to 20° reached such a degree of development (Table VI).

In this experiment the increase in weight of the testes was relatively unaffected by tem-

perature (Table V). In both experimental groups the mean weight of the testes was somewhat greater than the weight of approximately 7 mg. which Miller found to be the mean of animals taken in late December. The mean weight of the testes of animals kept at 20° was greater than that of the animals kept at 32°. However, the difference is not statistically significant; the standard error of the difference between the mean of the two experimental groups is only 1.68. It appears certain that in contrast to its lesser effects on spermiogenesis, 20° is fully as effective, and possibly more effective, than 32° in enhancing the photo-periodically induced increase in testicular weight.

TABLE VI

THE EFFECT OF TEMPERATURE ON THE SPERMATOGENIC CONDITION IN *Xantusia* EXPOSED FOR 21 DAYS TO 16 HOURS OF LIGHT PER DAY

Spermatogenic condition	20°C.	32°C.
Regression completed, but a few spermatozoa still in epididymis.....	—	—
Tubules beginning to regress.....	—	—
Tubules containing maximal number of spermatozoa.....	—	5
Many spermatids present, individual spermatozoa beginning to appear.....	5	4
Many spermatocytes and spermatids present.....	6	4
Only spermatogonia and spermatocytes present.....	3	3

It is of interest that the mean testicular weight of the animals kept at 32° is approximately twice as great after 21 days as after 50 days (10.4 versus 5.7 mg.). This indicates that the small testicular size of the animals kept at 32° for 50 days was due not to limited growth, but to involution, i.e., by the end of the 50-day experiment the testes had decreased from a previously attained peak in size.

DISCUSSION

Between 8° and 32°, the rate of spermiogenic development caused by artificially lengthened days increases directly with increasing temperature. However, the increase in testicular weight responds in a less regular manner: 8°

enhances the photoperiodically induced increase in testicular weight less than does 20°, but 32° is no more effective in this respect than is 20°. The increase in weight of testes between 8° and 20° is not unexpected because of the acceleration of metabolic rate with increase in temperature in reptiles. However, neither the significance of, nor the reason for the similar effects of 20° and 32° on testicular size are obvious. Since nothing is now known of the physiological mechanism for the photoperiodic response of *Xantusia vigilis*, speculation regarding the factors responsible for this situation is premature. However, it is appropriate to observe that, in this species, spermiogenic development and increase in testicular weight appear to be at least partially independent. At 32° mature spermatozoa appear in testes that are no more than one quarter of the typical weight of mature testes of animals in the breeding season.

Not only is the rate of spermiogenic development greater at 32° than at 20°, but the total length of the cycle is much shorter. When subjected for 7 weeks in mid-winter to 16 hours of light per day and maintained at 32°, the testes pass through a complete cycle of recrudescence and involution. Under similar conditions in late fall, the testes progress from the low level of activity typical of that season to the abundant production of mature spermatozoa in three weeks. The speed of this response compares very favorably with that of the English sparrow whose photoperiodic response (Bartholomew, 1949) is as pronounced as that of any wild vertebrate so far studied.

The failure of increased day length alone, increased temperature alone, or both increased day length and increased temperature together, to cause more than limited ovarian development indicates that the annual gonadal cycle of female *Xantusia vigilis* is relatively independent of both day length and temperature. However, the strong photoperiodic response of the male is probably more than a matter of laboratory interest. Despite previous assumptions that it was strictly nocturnal, Miller (1951) has found that in the winter this species feeds during the daytime. Therefore it is probably exposed to diffuse daylight at least. The fact that photoperiodic responses occur when the animals are in a torpid condition at 8°

shows that even the low morning temperatures common in the Mohave desert in winter would not prevent some photoperiodic response particularly since at this season the animals often are in relatively exposed positions among the leaves of fallen Joshua trees (*Yucca brevifolia*).

The importance of changes in day length in contrast to absolute day length in the photoperiodic response of this species is not known.

SUMMARY

The interaction of light and temperature in controlling the gonadal cycle of the ovoviviparous lizard *X. vigilis* was tested in two experiments involving over 250 animals. For 7 weeks in the winter and for 3 weeks in the late fall, groups of lizards were exposed to 16 hours of light per day while being maintained at 8°, 20° and 32° C.

In each experiment the females showed a limited increase in ovarian development. However, the photoperiodic response of the female is insufficient to take the ovaries beyond the first stages of reproductive development and it is virtually independent of temperature.

In each experiment the males showed a conspicuous acceleration in gonadal development.

The rapidity and extent of the photoperiodic response of males compares favorably with that reported for the most responsive birds. The speed of the male's response is dependent in part on temperature. In both the seven-week and the three-week experiment the degree of spermiogenic development increased with increased temperature.

Testicular weight was greater in animals kept at 20° than at 8°, but there was no significant difference between the effects of 20° and 32° on testicular weight.

Under natural conditions it is probable that neither temperature nor day length are of great importance in the annual ovarian cycle, but day length primarily and temperature secondarily may play a significant part in regulating the testicular cycle in the Mohave desert population of *Xantusia vigilis*.

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Tail Display in an Iguanid Lizard, *Liocephalus carinatus coryi*

LLEWELLYN T. EVANS

DATA obtained from a study of 24 specimens of *Liocephalus carinatus coryi* from Bimini Island provide new facts relating to territoriality and dominance. These facts confirm the basic hypotheses that most lizards exhibit a strong urge to hold and defend a territory, and that the bluffing or intimidating "dance" and the preliminary courtship "dance" of particular species are basically similar.

The familiar iguanid strutting posture, including lateral flattening of the sides of the body, distension of the gular fold of the throat, and head-bobbing, is present in *L. c. coryi*. However, an additional element is added to the "dance." The head-bobbing merges quickly into a "hobby-horse" rocking of the body while the tail is swept upward into a high spiral. This tail display was never observed in animals out of the presumed visual range of others of the same species. It was best shown by an individual as it challenged another, or while in courtship, although a momentary coiling of the tail unaccompanied by other aspects of the strutting "dance" sometimes occurred as one individual passed another or approached a group. The results of this study indicate that the spiral coiling of the tail is an integral part of the behavioral pattern of the species.

PROCEDURE

After weighing and marking each specimen, with colored spots and toe amputations for future identification, the entire group of 24 lizards was confined in a glass-sided terrarium (9'10" x 4'6") which had 4 inches of sand on the bottom. Three elevations in the cage were used by the lizards as lookouts. These were designated as stations: A, a large conch shell

at one end of the cage; B, a group of gray stones in the middle; C, an irregular stack of red sandstone slabs at the other end. A series of light bulbs suspended above the cage provided illumination. Dishes of fresh water and others with meal worms provided a constant supply of drink and food. All observations and photographs were made behind a screen that hid the observer from the subjects.

The following lizards shared the cage with *L. c. coryi*: 4 *Holbrookia*, 2 *Phrynosoma*, 3 *Cnemidophorus* and 3 *Eumeces*. Three species of toads were also present. Toleration of one species for another was noted. All specimens ate well, and except for intraspecific domination of one lizard by another, none was molested by others. It was possible to observe intraspecific courtship or intimidation taking place by 2 species simultaneously with no apparent disruption or interference of the pattern of one species by the other.

By merely observing the group, considerable data were collected concerning the behavior of the dominating animal, but little or no evidence could be obtained on the presence of a hierarchy because the lesser males appeared to be inhibited. To elicit displays by other individuals, the dominating male was removed from the terrarium. Soon a social shuffling occurred as the animals split up into small groups, each dominated by a strutting male. Readmission of the dominant male to the terrarium resulted in a series of abortive displays as each lesser male challenged the newcomer. In demonstrating his superiority over his rivals, the newcomer seemed to draw the lizards into a socially homogeneous group again, with no lizard attempting to dispute the authority of the new "tyrant."

Evans (1951a) has given examples in other species of group behavior changing as a result of shifts in dominance from one individual to another.

The following protocols, selected from hundreds of observations, depict the social behavior of *L. c. coryi* and the role played by the tail-coiling habit in courtship and intimidation.

PROTOCOLS

Feb. 7-17. Male No. 1 (35.5 grams), largest specimen of the group, repeatedly challenges the others by flattening his sides laterally, distending this throat, and holding high his coiled tail. He displays successively from stations A, B and C, and struts from one end of the terrarium to the other at least 8 times daily, in what seems to be guarding "duty" (Fig. 1). In a fight with male No. 2 (31.7 g.) on Feb. 9, No. 2 emerged with his tail bitten off, leaving a stub 2 inches long. No. 2 stays in the sand with only his head above ground Feb. 9-17.

Feb. 20. Male No. 1 challenges from station B; No. 2, 7 feet away, immediately burrows into the sand. No. 1 ran toward him with tail coiled high.

Mar. 13. Male No. 1 is removed from the terrarium.

Mar. 14. Male No. 2 struts with his short tail curved stiffly upward. He challenges from various points in the terrarium, in a manner similar to No. 1. Male No. 9 (17.5 g.) challenges a few lizards at 1 PM, while No. 2 is at the other end of the terrarium.

Mar. 15-29. No. 2 is repeatedly on guard on one or another of the 3 stations. He traverses the area frequently. He courts female No. 6 (20.0 g.) and finally copulates with her, grasping her neck with his mouth, and pushing his tail beneath hers to bring their cloacae into contact.

Mar. 30. No. 1 is replaced in terrarium at 2:30 PM. Within 10 minutes No. 2 comes strutting, mouth open, as if to bite No. 1; but No. 1 stands with head high and tail coiled. No. 2 turns away to challenge from station B. At 2:55, No. 1 emerges from beneath the rocks of station C and No. 2 struts toward him. No. 1 struts perfunctorily, raising his tail in a watch-spring spiral, then runs back to station C. When No. 2 approaches, No. 1 quickly faces him, raises his tail in the usual spiral, and then

departs to the far corner, where he courts a small female (Fig. 2), then rests in the shade of station C. At 3:10, No. 1 reappears and No. 2 runs toward him, circling and strutting. No. 1 struts in like fashion with his tail raised in a precise spiral. As the contestants circle, they open their mouths, and when within 4 inches of each other both charge and exchange bites swiftly. Finally No. 1 returns to station C and No. 2 to station B.

At 3:25 PM No. 2 starts walking back and forth with his snout pressed against the glass of the terrarium. He starts running as No. 1 approaches him and, in the ensuing chase, No. 1 tries to bite the flanks or tail of No. 2. During this chase all the other lizards (*L. c. coryi*) disappear by digging into the sand or hiding beneath the 3 stations. At 3:50 male No. 2 digs into the sand and No. 1 remains in undisputed control of the terrarium. At 5:00, males No. 1 and 2 are removed and placed in separate cages.

Mar. 31-Apr. 7. Four smaller males, designated as No. 3 (29.1 g.), No. 4 (26.0 g.), No. 5 (22.6 g.), and No. 8 (18.5 g.), display before scattered groups of lizards. No open combats are observed but the displays include much dramatic tail coiling (Fig. 3).

April 7. At 2:35 PM No. 2 is replaced in the terrarium. At 2:50, No. 2 challenges and No. 3 emerges from station C and struts in a circle around No. 2. Male No. 2 returns the challenge, then moves up onto station C. He is followed by No. 3 who retreats as No. 2 struts. Ten minutes later, No. 3 advances in a stiff strut but disappears beneath station B as No. 2 again returns the challenge. Later, No. 3 is observed scratching at the glass wall of the terrarium, as if trying to escape. But 10 minutes later No. 3 again approaches No. 2 but runs away to scratch at the glass as No. 2 struts. No. 3 is removed from the terrarium on April 10.

April 13. Male No. 3 is replaced in the terrarium at 3:49 PM. He runs to station C and rests. Soon male No. 4 begins strutting near No. 3, then turns to court a female. No. 3 fails to return the challenge.

April 14. Males No. 2 and 3 are removed from the terrarium.

April 17. Male No. 3 is replaced in the terrarium at 12:45 PM. He immediately goes in the conch shell and stays there until dark.

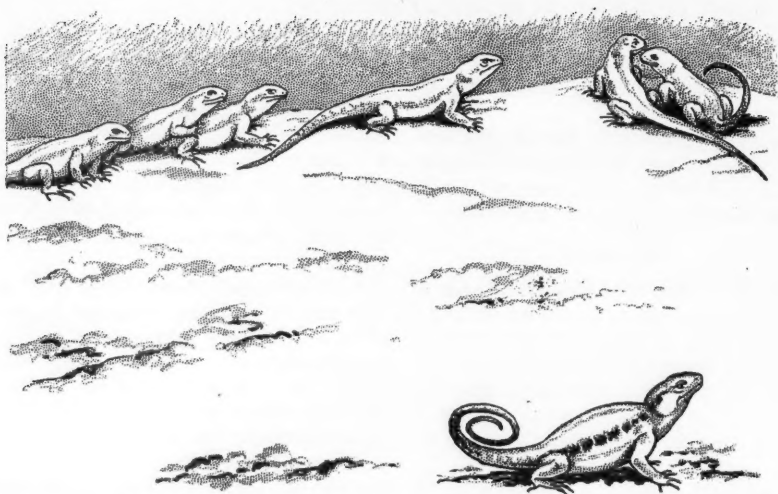


Fig. 1. *Liocephalus c. coryi*. Feb. 14. Male No. 1 challenges the group shown, as well as three specimens which are in the foreground but not shown in the drawing.

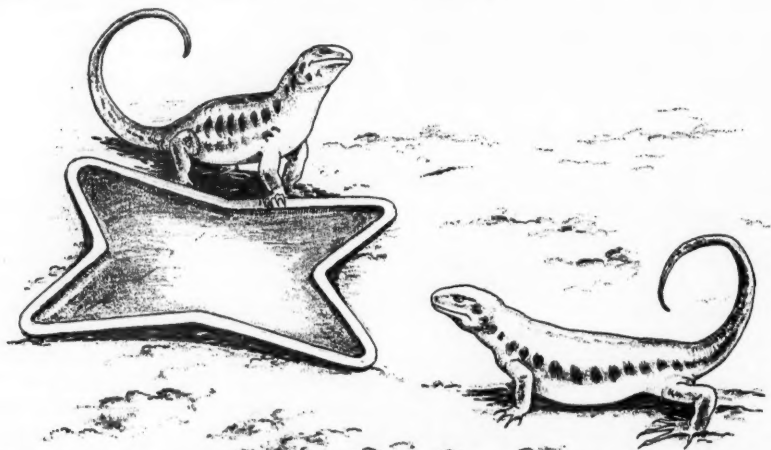


Fig. 2. *L. c. coryi*. Mar. 30. Having just intimidated male No. 2, male No. 1 (by the dish of water) courts female No. 6 (in foreground). The tail display is similar in both sexes but the body-posture of the female is more relaxed. Accurate copy of photograph.



Fig. 3. *L. c. coryi*. April 5. In the absence of males No. 1 and 2, male No. 3 displays before three lizards on the pile of red sandstone (Station C). Accurate copy of photograph.

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At 2:15 PM, No. 2 is replaced and is challenged within 15 minutes by No. 4. At 2:30, No. 5 challenges No. 2 who returns the challenge by means of the high curved tail, then walks up onto station B. At 3:30, female No. 6 approaches male No. 2 with tail coiled high, then rests beside him. No. 2 courts her in the usual fashion, his short tail curved upward. Four minutes later, No. 5 comes close but No. 2 ignores him. Males No. 2 and 3 are removed at 5:00 PM.

April 26. Male No. 2 is replaced in the terrarium at 1:40 PM. Five minutes later he is strutting in the usual fashion from stations B and C. At 2:50, male No. 1 is replaced. He had been confined in a small cage for almost a month; but in 3 minutes he starts to feed. No. 4 challenges with upraised tail; No. 1 returns the challenge and No. 4 retreats. Seven minutes later, No. 2 challenges No. 1, who returns the challenge. The two big males circle and strut, mouths open and tongues partly out. The tail of No. 1 drops to the sand and No. 1 bites No. 2, who then retreats and digs into the sand. Male No. 1 is removed at 5:00 PM.

May 5. When No. 1 is replaced he dominates the terrarium as usual. No. 2 hides. Males No. 1 and 2 are removed at 5:00 PM.

May 7–October 26. In the absence of the two largest males, those designated as Nos. 3, 4, 5 and 8 strut intermittently before different groups of lizards of the same species. However, none appears to dominate the entire terrarium.

Oct. 27. Males No. 1 and 2 are replaced. Although he is markedly less pugnacious than before, No. 1 dominates No. 2 who digs in and stays in the sand as long as No. 1 stays near.

Nov. 29. No. 1 still dominates No. 2 who remains in the sand.

Nov. 30. No. 2 remains in the sand as No. 1 struts on station A. None of the other lizards displays in the presence of No. 1. He severely mutilates the foreleg of male No. 8 with his jaws.

DISCUSSION

The symmetrical coiling of the tail in *Liocephalus carinatus coryi* was regularly observed as a part of the challenging ceremony when one male approached another. This caudal display was accentuated by the resident male when a second male was replaced in the cage after an absence of a few days or weeks. The antagonistic

response of the resident in these circumstances was similar to that of the resident male of *Anolis sagrei* when a strange male was placed upon its natural territory in the field (Evans, 1938a) or in its cage (Evans, 1938b). The resident male of *Sceloporus occidentalis* responded similarly to male intruders (Fitch, 1940).

Both males and females of *L. c. coryi* at different times were observed to initiate courtship with a caudal display. It was also noted that tail-coiling by the male, in front of the female, preceded copulation. The significance of the courtship ceremony as a preliminary phase in the mating of lizards, as well as the active participation by the female in the courtship "dance," has been stressed by Evans (1938a, b, 1951a, b), Fitch (1940), Mertens (1929), Newman and Patterson (1909), and Oliver (1948). These facts are opposed to the contentions of Noble and Bradley (1933) that the female takes a purely passive role in courtship and that the male's display is important only for the intimidation of rival males.

SUMMARY

The preliminary courtship of the lizard *Liocephalus carinatus coryi* is similar to that of other iguanids, except that, in addition to the usual distension of the throat and flattening of the sides, both males and females raise the tail into a symmetrical flat spiral. The tail is also displayed in coiled fashion by one male while intimidating another, especially if the latter is invading the territory of a resident.

A loose hierarchy was shown to exist among the males under study. This hierarchy comprised the following numbered males, listed in numerical order of dominance: 1, 2, 3, 4, 5, 8, and 9. The males numbered 1 and 2 weighed 36 and 31 grams respectively, and were unquestionably fully mature. The others weighed between 17 and 29 grams and were probably young adults or post juveniles. This assumption is based on the comparison of their behavior with that of the two largest males.

In the absence of one or both of the biggest males, the smaller ones exhibited some degree of dominance toward groups of lizards. Some of them also strutted in challenging fashion before males No. 1 or 2 when the latter were replaced in the terrarium after an absence of several days or weeks.

The author is grateful to the Illustrators' Corps of the American Museum of Natural History for the preparation of the figures.

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AMERICAN MUSEUM OF NATURAL HISTORY,
NEW YORK 24, NEW YORK.

Herpetological Notes

THE CROCODILE IN THE EVERGLADES NATIONAL PARK.—Three or four years ago the possibility of extermination of the American crocodile in the United States seemed very real. Inclusion of Florida Bay in the Everglades National Park in February of 1950 provided sanctuary for this vanishing reptile whose ordinary range in the continental United States consists of a mere hundred miles or so of the southeastern coast of Florida. It is intended here to present notes on its natural history and current status in the area of the park. This information was accumulated during three years of field work on some of the larger vertebrates of the park.

William Piper has permitted me to include important notes which he has kept on captive Florida crocodiles in his zoological garden of southern Florida wildlife at Bonita Springs. From his years of special effort in gathering together what he believes to be the largest collection of this crocodile in the United States, he has also contributed other valuable observations. The following persons contributed, or shared in the contribution of, observations used in plotting the distribution chart (the numbers in parentheses refer to locations on the chart): Robert P. Allen (27) and Herbert Alley (15a) of Tavernier, district ranger Paul Barnes (1), superintendent Daniel B. Beard (2), Mr. and Mrs. W. W. Blankenship of Richmond, Va. (23), acting district ranger David Bogart (7, 14), Charles M. Brookfield of Miami (12), fire control aide Charles Damm (1), Charley Davis of Tavernier (4), the late Rollin Davis of Lake Surprise (19), park naturalist Willard E. Dilley (1, 2, 11, 16, 17), Jack Gautier of Princeton (25), Claude Lowe of Tavernier (13), district ranger Ralph Maxwell (1, 4), skiff concession operator James McGilvary (18), park mechanic James Parker

(21), park warden M. Bernie Parker (3), U. S. Fish and Wildlife Service under refuge manager Jack Watson (5, 6, 11, 22, 24), and commercial fisherman Fred Woodard (20). To these persons the writer is sincerely grateful.

DISTRIBUTION.—The most conspicuous feature of crocodile distribution in the Everglades National Park is the lack of records around Cape Sable and up the western coast. This is despite the fact that the writer and most of his informants have spent more time about Cape Sable and the lower western coast than the portion of Florida Bay known to be inhabited by crocodiles. Maxwell and the writer awoke at anchor in the mouth of the Little Shark River, May 25, 1949, and saw the eyes and snout of an adult crocodilian a hundred feet or so from us. It looked as much like an alligator as not, but it is most unusual to find an alligator in such salty water. Bernie Parker observed an unidentified crocodilian in very salty water farther up the coast, but in his exceedingly intimate acquaintance with the wildlife of the mangrove coast obtained by constant patrolling and observation, he has not certainly encountered the crocodile there. These unidentified crocodilians were very likely alligators (Fig. 1).

For years William Piper advertised that he would call for and pay for a live crocodile anywhere in south Florida. Where fishermen caught a crocodile in their nets, they had only to tie it up and call for the Piper brothers to come and pick it up from the dock. Yet in spite of the proximity of Bonita Springs to the commercial fishing operations at Naples, Goodland Point, Everglades, etc., crocodiles came only from the lower eastern coast and Florida Bay. If there is a crocodile record from Collier County

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(Carr, 1940, A contribution to the herpetology of Florida: 68), it must be of an escaped captive or a stray. Apparently there is no evidence that it occurs naturally anywhere on the Florida west coast.

occasionally took crocodiles indicates that this big reptile moves about in the open waters of Florida Bay. The average depth of water in Florida Bay is about 4 feet, and maximum depth of open water is

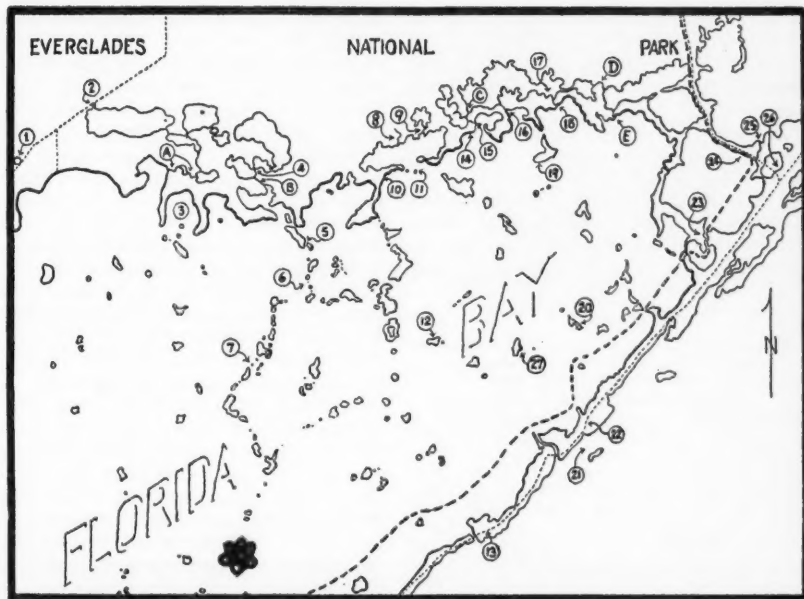


Fig. 1. Crocodile distribution in Everglades National Park. (Heavy dashed line indicates park boundary; light dashed lines indicate roads. Places where crocodiles have been reported are pointed out by numbers. Letters show creeks mentioned in text but not inhabited at present by crocodiles.)

1. Coot Bay Pond. February 2 to August 1, 1950, when replaced by alligator
2. West Lake Pond. Seen in water frequently during December, 1948.
3. Rankin Bight. Two recorded in patrol log for June 14, 1945.
4. Oyster Creek. Two observed in water August 21, 1950.
5. Crocodile Dragover. One seen sunning on bank in 1949.
6. Samphire Keys. A skinned carcass about 13 ft. long found in 1937.
7. Cup-o-whiskey Key. Active nest May 10 to August 6, 1951.
8. Taylor River. Sunning places on banks October and December 1949.
9. East Creek. Eight sunning places counted on banks April 26, 1951.
10. Madeira Point Beach. Nest remains found October 25, 1949. Crawls observed April 26, 1951.
11. Un-named key. Nest remains observed October 28, 1947.
12. Manatee Keys. Observed in water about January 1946.
13. Little Snake Creek, Plantation Key. Destructive to chickens about 1948.
14. Cat Track Beach. Nest remains observed October 13 or 14, 1950.
15. Mud Creek. (a) One observed sunning on bank about April 1, 1951. (b) Counted 3 sunning places May 1, 1951.
16. Davis Creek. Counted 16 sunning places on bank in current use May 29, 1951.
17. An un-named passage in Joe Bay. One sunning place on bank May 29, 1951.
18. Trout Creek. Saw two in water in evening about April 1, 1951.
19. Deer Key. Fourteen footer observed about 1900.
20. Butternut Keys. Nests found on shell sand beaches.
21. Open water near Tavernier. Passed one lying on the bottom September 12, 1950.
22. Tavernier. Five-foot four-inch highway casualty November 9, 1951.
23. Dusenbury Creek. Adult plunged off bank June 12, 1951.
24. Cross Key. Large adult November 4, 1949, and other times.
25. Jewish Creek. Few individuals observed during summer of 1951.
26. Lake Surprise. Saw eleven-footer January 22, 1950.
27. Bottlepoint Key. Several adults heard bellowing. Tracks seen.

A, Alligator Creek; B, McCormick Creek; C, Squeeze Creek; D, Green Heron Creek; E, Rocky Creek (also called Shell Creek).

HABITAT.—In Florida Bay Robert P. Allen (1947, Flame birds: 10) found crocodiles to be active on Bottlepoint Key at night. He heard several individuals bellow as do alligators. The fact that drag seines, which formerly operated in park waters,

11. A number of broad mud banks, crooked, branching, and island-dotted, occupy perhaps a third of the area of Florida Bay and break up the deeper water areas into twenty-five or thirty basins known among the commercial fishermen as "lakes." While

these "lakes" are nearly all interconnected by natural passes or channels through the banks, these channels are usually small. The three-foot tide at the western end of Florida Bay is muffled by these banks so that there appears to be no tide at all in the northeastern part. Water levels do change with the direction of a steady wind. Although it may be merely coincidence, the most evidence of crocodile presence in the park is from that portion of Florida Bay which lacks tide.

Florida Bay is, of course, salt water. The crocodile apparently restricts its activities in southern Florida rather closely to salt waters, sometimes moving with the rising salinity up streams into the mainland toward the end of the dry season. Since Schmidt (1924, Field Mus. Nat. Hist. Publ. Zool. Ser., 12 (6): 85) found this species thriving in a freshwater

TABLE I

COMPARISON OF DIAMETERS (IN MM.) OF EGGS OF *Crocodylus acutus* FROM FLORIDA, PANAMA AND HONDURAS¹

Locality	Number of eggs	Long diameter			Short diameter		
		Mean	Max.	Min.	Mean	Max	Min.
Florida	12	72.8	77.3	68.6	47.7	49.1	46.6
Panama	14	79.0	83.0	75.0	52.0	52.5	50.0
Honduras	22	...	76.0	70.0	...	45.5	42.0

¹ Data for Panama are from p. 430 in Breder (1946, Amphibians and reptiles of the Rio Chucunague drainage, Darien, Panama, with notes on their life histories and habits. Bull. Amer. Mus. Nat. Hist., 86: 379-435); and for Honduras, from Schmidt (*op. cit.*: 92). The Honduras figures actually represent the sizes of the largest and smallest eggs of the sample of 22 and are consequently not directly comparable to the others.

lake about 100 feet above sea level and occurring even 2,000 feet above sea level (*op. cit.*: 92) in Honduras, it appears that in Florida intolerance between this species and the alligator may explain the rather close restriction of the former to salt water. The habitat of the crocodile in Florida Bay does nevertheless resemble its habitat in Lake Ticamaya (Schmidt, *loc. cit.*) in several ways. Among these are the exceeding shallowness for so considerable an expanse of water, softness of the bottom (a marl ooze in Florida Bay), and green color and opacity of the water, apparently due in Florida Bay to suspension of fine particles of the limey bottom ooze stirred up by schools of mullet and wave action. There are also beaches. Fresh winds holding constant from one direction for a day or more create wind "tides" in Florida Bay lowering water level in up-wind areas and raising it in down-wind bays and "lakes." High water levels of these wind tides doubtless contribute to the construction of the shell beaches, and one of the finest of these, Madeira Point beach, occupies a long, slightly indented shore

which faces the prevailing southeast wind across 5 miles of open water.

Nearly all of our recorded observations of crocodiles were obtained in passes or "creeks" between keys. Wind pressure forces water through these passes and keeps them cleaned out and deep. Presumably the crocodiles feed upon the fish which congregate in these deep channels. Where the banks of such channels are above water level, there are places on them that crocodiles have worn bare by lying out on the bank to sun. Dimock (1915, Florida enchantments: 90, 92) provides excellent photographs of two such sunning spots, and describes caves in these banks beneath the sunning places, under the water, in which the big reptiles take refuge, and from which he took several. In some of these passages the marl banks rise straight up to twelve and more inches above the water. On these there are long vertical claw marks made by the crocodiles in scrambling up to their places to sun. During the period of the writer's observations, such signs of crocodiles occurred in Taylor River and East Creek of Little Madeira Bay, Mud Creek of Alligator Bay, and Davis Creek of Davis Cove. The writer has searched closely but in vain for such signs in Rocky Creek (also called Shell Creek), Green Heron Creek, Trout Creek, Squeeze Creek, McCormick Creek, and Alligator Creek. Conditions seem especially suitable for such crocodile use in Rocky Creek and Alligator Creek. Fishermen make rather frequent use of these two creeks, and in the past have probably kept crocodiles killed out of them. Since Florida Bay was only taken into the park area in February of 1950, it is perhaps too early to expect the crocodiles to have increased and moved into these creeks.

NESTING HABITS.—The breeding habits of *Crocodylus acutus* in Florida are not well known.

Willoughby (1898, Across the Everglades: 73) found two crocodile nests in southern Florida close to the water's edge. "A hole is scooped out of the dry sand low enough to insure the proper amount of moisture (independent of rains). . . . The eggs are then laid in layers and the sand smoothed down perfectly level, which makes the place very difficult to find. . . . The nests . . . contained, respectively, fifty and seventy-five eggs." It seems likely that these numbers are estimates from memory rather than counts made and recorded at the time of finding the nests.

Between the Whipray Keys and Buttonwood Keys in Florida Bay, on a tiny shell sand island known only as Cup-o-whiskey Key, park ranger David Bogart found a crocodile nest on May 10, 1951. The writer and fire control aide Ted Hackett visited the nest on May 16 and 17 and found it to be in a pile of sand eleven feet in diameter. The site was a bare spot fifty feet from the water and sepa-

rated from it by a screen of red mangrove, *Rhizophora mangle*, and bay cedar, *Suriana maritima*, through which there was a barely evident, crooked path between water and nest which could only have been made by crocodile(s). Ground level at the nest site exceeded that at the water's edge by 25 inches, and the sand pile was $16\frac{1}{2}$ inches high. From the top of the sand pile down to the top of the highest egg was $10\frac{1}{2}$ inches; from there to the bottom of the lowest egg was $8\frac{1}{2}$ inches. (Vertical measurements are by hand level.) The sand pile was therefore constructed, at least in part, before this clutch was laid, and the eggs were laid in a hole dug into it. The horizontal spread of the clutch

TABLE II

WILLIAM PIPER'S RECORDS OF EGG LAYING BY *Crocodylus acutus* IN CAPTIVITY AT BONITA SPRINGS, FLORIDA

Sizes of animal laying the eggs are estimates to the nearest half of a foot. Some eggs were laid on each date listed, but actual egg counts were made only on certain dates

Dates clutches were laid	Number of eggs	Size of animal
March 12	..	..
21	..	..
21	..	..
25	35	$8\frac{1}{2}$
30	21	$7\frac{1}{2}$
April 1	22	$7\frac{1}{2}$
10	..	..
10	..	..
11	..	..
12	..	..
22	..	..
May 7	40	9
8	..	..
10	34	$8\frac{1}{2}$

was $12\frac{3}{4}$ by $17\frac{1}{2}$ inches. Since sand did not fill the interstices of the lower part of the clutch, the eggs evidently all were laid at once and then covered. The sand about them was clean, and the crocodile had evidently made no attempt to include detritus or leaf mold in the nest.

It was abundantly clear that the crocodile had made, or at least added to, this sand mound; on every side of it there were long scooped-out depressions where the animal had evidently faced away from the mound and thrown sand back upon it with both front legs.

We removed and counted the 56 eggs, marking each with a pencil so that we could put them back right side up (Table I). Two sets of twelve each weighed 1115 and 1105 grams. We opened one egg on May 17 and found it fresh.

On July 26 Bogart and the writer re-visited this nest. These visits each involved a round trip of 30 nautical miles in an open boat. An egg opened on this date contained a young crocodile 227 mm. long which had its eyes and mouth open. The yolk attached appeared equal to the crocodile in bulk. In taking out two dozen eggs to weigh, we easily distinguished several rotten ones and discarded them. One dozen of good eggs weighed 1010 grams, a second dozen 1020, which indicates a loss of about 8 grams per egg during 70 days of incubation. About a third of the good eggs handled at this time had one or more cracks in the limey part of the shell. Some, but not all, of the rotten ones were cracked.

On July 30 we removed the top egg from the nest and opened it to note progress. The enclosed young crocodile was 214 mm. long (Table III) and proved quite lively. A large portion of the egg yolk

TABLE III

MEASUREMENTS (IN MM.) OF FLORIDA SPECIMENS OF *Crocodylus acutus* NEAR HATCHING

Two taken from eggs on August 6 freshly dead, and one taken from egg on July 30 which lived until August 12

Measurement	August 6	July 30	August 12
Total length.....	232	238	214
Anus center to tail tip....	113	117	102
Eye to nostril (center)....	18	17	16
Length of fore limb.....	31	31	28
Length of hind foot.....	27	27	24
Length of gape.....	33	33	33
Length of open venter....	34	35	..

was in the process of being enclosed within the abdominal wall, but another portion not quite so large remained separated from this by a constriction in the membranes several centimeters long. This young crocodile died of neglect after 12 days.

On August 6 Bogart and the writer examined this nest again. A dozen apparently good eggs weighed 955 grams, indicating a further loss in weight of about 4 grams per egg in 11 days. On this occasion several high-pitched grunting noises, similar to the call of the baby alligator, were heard from the still un-hatched young crocodiles as we opened the nest. One of the two young crocodiles whose shells I opened to note progress, grunted several times before the shell was removed, but neither showed any further signs of life (Tables I, III).

On August 14 the writer re-visited this nest and opened all of the remaining eggs. None had hatched, and not one contained a live crocodile. Eight eggs contained embryos which had attained approximate hatching size, and about three of these were so freshly dead as to have no odor of decay. Eight or

ten other eggs contained embryos which were about half hatching length. In the remainder there were embryos without the scaly skin developed, or no embryo at all.

The lower eggs, which had not been disturbed since the writer's first visit, were now found to be enmeshed in a mat of rootlets, presumably from a railroad vine (*Ipomea pes-capri*) which had sprung up on the nest mound. Many of the lower eggs were so tightly imbedded in a matrix of rootlets that hatching seemed quite impossible. One of these eggs did contain a crocodile of hatching size. Upon close examination, without magnification, it appeared that the tips of the rootlets were closely applied to the pores of the rather rough, porcelainous shell, but did not actually pierce it.

Attempting to discover whether the female crocodile attends its nest as does the American alligator, the writer and Ranger Bogart swept the sand clean of tracks on and about the mound each time that we left it. There were tracks on and about the nest mound when Bogart found it on May 10. Hackett and I found that no crocodile came to the nest during the night of May 16 while we were camped on the key about 50 yards away, screened by dense red mangrove, buttonwood (*Conocarpus erecta*), etc. Neither had it been visited when Bogart and I returned to the Key on May 18. There were tracks on and about the nest mound, however, on July 26, July 30, August 6, and August 14. Particularly on the last two dates it was apparent that the crocodile had crawled over and about the nest repeatedly, leaving many tail marks as well as tracks.

James McGilvary saw seven very young baby crocodiles together in Taylor River near its mouth on September 25, 1951.

Ranger Bogart found the remains of a crocodile nest on Cat-track Beach just a quarter mile south of Mud Creek on October 13 or 14, 1950. It had egg shells scattered about on the surface. On May 25, 1951, he found another crocodile nest begun on the same beach, this one with a lot of brush and debris mixed in with the sand.

On October 25, 1949, the writer found the remains of two crocodile nests in the shell sand of Madeira Point beach. Both of these had egg shells scattered about them. On April 26, 1951, the writer found ten places where a crocodile had ascended or descended this beach. All of these evidently climbed to the height of the beach (2 ft.?), usually straight out from the sea a distance of 30 to 50 feet. Once back there, some wandered 70 or 80 feet parallel to the water's edge. It appeared that they (or it) had been attracted to wide, bare places on the summit of the dune, and one crawled in a figure 8 on such a place. There was only one evidence of digging, a mound of sand 3 or 4 inches high and $1\frac{1}{2}$ by 3 feet

in extent. It contained no eggs. Camping on this beach May 1, 1951, the writer searched its whole length but found only two more places where a crocodile had come out of the water. One had wandered about on the low dune perhaps 150 feet before re-entering the water; another had crawled only 45 or 50 feet. The writer looked once more on this beach for nests on August 22, 1951, but again in vain. Where clear these tracks were three-toed and there was a keel-mark made by the tail.

Watson and Dille examined the remains of a crocodile nest on a little key in the mouth of Little Madeira Bay on October 28, 1947. There were fragments of the egg shells scattered about it.

EGGS.—The Cup-o-whiskey Key crocodile nest contained 56 eggs; when fresh these had an average weight of 92.5 grams. The diameters of the eggs average less than those of the same species from Panama (Table I). Until something is known on how much egg size may vary in one locality, no geographic significance can be attached to this considerable difference.

William Piper's captive Florida crocodiles have laid eggs even though they had not the facilities for building nests. From 1944 to the present (November, 1951) he had recorded the dates on which these eggs were laid and in instances where it was possible to count them, the number of eggs laid. These records doubtless define rather nicely the egg-laying season (Table II). One of his captive Florida crocodiles laid a clutch of eggs in which all were large and double-yolked. He gives me January 22 through February 16 as the season for mating.

SUMMARY.—The American crocodile, *Crocodylus acutus*, is well distributed in Florida Bay, has been protected there since February, 1950, by inclusion of that area in the Everglades National Park. This species is not known to occur naturally on the west coast of Florida. For sunning it seems to prefer the high, sheltered banks of creeks and passes between bays in the tideless portion of Florida Bay most remote from the presence of man. It makes its nest on the shell sand beaches in this area. The one active nest found was made in a considerable mound of sand thrown up by the crocodile. No decaying vegetation was included in the nest. After the discovery of an active nest on May 10, 1951, it was inspected 6 more times, and on August 14 all life in it had failed. An adult crocodile crawled about and over the nest between the last five inspections. The eggs lost weight during incubation. Sizes of eggs and hatching-age (?) crocodiles are tabulated. Fourteen dates of egg-laying by captives range from March 12 to May 10, and numbers of eggs in eight clutches (two from literature) range from 21 to 56. Remains of old nests were found at four other sites in Florida Bay. In late April and early May crocodile tracks

were found ascending a beach from the sea as if the crocodile had been seeking a nesting site.—JOSEPH C. MOORE, *Everglades National Park, P.O. Box 275, Homestead, Florida.*

STORAGE OF SPERM IN THE FEMALE CHAMELEON *MICROSAURA PUMILA PUMILA*.—The female diamond back terrapin is known to store sperm (Hildebrand, 1929, Bull. U. S. Bur. Fisheries 45: 34). Records of storage of sperm by female snakes have been given by Woodward (Proc. Zool. Soc. London, 1933: 189-90), by Trapido (1940, COPEIA (2): 107-09), by Rahn (1940, COPEIA (2): 109-15), by Haines (1940, COPEIA (2): 116-18) and by Carson (1945, COPEIA (4): 223). Haines includes a summary of observations on Malayan snakes by Kopstein (1938, Bull. Raffles Mus., 14: 81-167). Both Rahn and Trapido give proof of sperm retaining activity in the uterus for at least three months. For female lizards, I have found no record of sperm storage.

Varying sizes of embryos in the same oviduct in females of *Chamaeleo bitaeniatus ellioti* and *C. b. leikiapiensis* have been described by H. W. Parker (1940, Ann. Mag. Nat. Hist. ser. 11, 5: 268-70). He says:

... successive pairings and fertilizations might be suggested, but it is difficult to believe that, of three eggs lying in one oviduct (*leikiapiensis*), the extremes could be fertilized and the centre one remain infertile until a later date.

The asymmetry of one of the very immature embryos in *leikiapiensis* and the disintegrated yolk in the right oviduct of *elliotti* indicates that where the development is retarded all is not well, and it is not improbable that these individuals never reach their full development but are aborted. It is nevertheless obvious that the rate of development of all the embryos of one clutch of eggs is not uniform, and that there is a tendency for the contents of one oviduct to be very much retarded as compared with the other. . . . This opens up the possibility that there may be two, or even more, partitions resulting from a single pregnancy, and retarded development of this nature may be the explanation of a phenomenon which has been noted in Chelonians (Hildebrand, 1928) and Vipers (Woodward, 1933), viz., several successive clutches of fertile eggs laid after the female has been segregated from the male.

In 1939, I found in *Microsaura pumila pumila* (Daudin), the dwarf chameleon of South Africa, and in *Chamaeleo jacksoni* Boulenger of Kenya the same condition of partially developed embryos along with fully developed fetuses. In two dwarf chameleons I have seen immature embryos extruded at the time of birth of young.

In addition there seems to be storage of sperm. A dwarf chameleon, captured on January 5, 1940, and caged with other females, produced 6 live young

and 2 immature embryos on February 23. On April 26 and May 3, after being injected with 2 units of pituitrin, she aborted a total of 5 eggs, at least 3 of which contained an embryo less than 2 mm. in length. During hot weather in July, she received too much sun. On July 16-19, in her cage were found 8 embryos, unfortunately dried hard to about 7 mm., but at least 3 plainly showing large dark eyes. The small size of the embryos on April 26 and the much greater size and development of those in July indicate a clutch of eggs quite distinct from that which produced live young in February. Storage of sperm seems a logical explanation.

Four months later, on November 12, the same female aborted 13 eggs measuring $8 \times 5 \times 5$ mm., but they were without trace of embryos. On March 24, 1942, she again deposited eggs without trace of embryos. She wiped off these eggs on a branch as she would have young. Three times, 2 eggs were deposited together. She underwent much more convulsive movement than when she deposited young.—S. R. ATSATT, *Department of Zoology, University of California, Los Angeles, California.*

NEW DISTRIBUTIONAL RECORDS FOR REPTILES AND AMPHIBIANS IN SOUTH CAROLINA.—The following amphibians and reptiles, not hitherto reported in print from this part of South Carolina, have been obtained from the Savannah River Operations Area located in Aiken and Barnwell counties.

AIKEN COUNTY

REPTILES.—*Eumeces fasciatus* (Linnaeus), *Eumeces laticeps* (Schneider); *Diadophis punctatus punctatus* (Linnaeus), *Pituophis melanoleucus melanoleucus* (Daudin), *Lampropeltis getulus getulus* (Linnaeus), *Natrix sipedon fasciata* (Linnaeus), *Thamnophis sauritus sauritus* (Linnaeus), *Agkistrodon mokeson mokeson* (Daudin), *Agkistrodon piscivorus* (Lacépède), *Sistrurus miliarius miliarius* (Linnaeus); *Terrapene carolina carolina* (Linnaeus), *Pseudemys scripta scripta* (Schoepff); *Alligator mississippiensis* (Daudin).

BARNWELL COUNTY

AMPHIBIANS.—*Desmognathus fuscus auriculatus* (Holbrook), *Eurycea bislineata cirrigera* (Green), *Eurycea longicauda guttolineata* (Holbrook), *Plethodon glutinosus glutinosus* (Green), *Necturus punctatus* (Gibbes), *Siren intermedia intermedia* LeConte; *Bufo terrestris* (Bonnaterre), *Acris gryllus gryllus* (LeConte).

REPTILES.—*Anolis carolinensis* Voigt, *Sceloporus undulatus undulatus* (Latreille), *Eumeces fasciatus* (Linnaeus); *Diadophis punctatus punctatus*

(Linnaeus), *Heterodon contortrix contortrix* (Linnaeus), *Coluber constrictor constrictor* (Linnaeus), *Natrix sipedon fasciata* (Linnaeus), *Natrix taxispilota* (Holbrook), *Ambystoma piscivorus* (Lacépède), *Crotalus horridus horridus* (Linnaeus); *Sternotherus odoratus* (Latreille).—WM. E. HOY, J. T. PENNEY, H. W. FREEMAN, W. R. KELLEY, AND N. H. SEEBECK, JR., *University of South Carolina, Research Team on Contract No. AT (07-2)-11, Atomic Energy Commission, Columbia, South Carolina.*

FOOD OF THE SALAMANDER TRITURUS VIRIDESCENS VIRIDESCENS.—From July 1 through 15, 1952, in a search through the cold lakes in the environment of Highlands, North Carolina (altitude 4100 feet) for crustacea of the family Palaemonidae, an interesting incidental observation was made. It appears that one of the commonest inhabitants of these lakes is the adult of *Triturus viridescens viridescens* (Raf.). Brought to the laboratory and placed in clear water, these salamanders shed empty shells of a small sphaeriid tentatively identified as *Pisidium abditum* (Hold.). The observation was so intriguing that a careful search was made of all the lakes in the environment. Specimens of *Triturus* were examined from eight lakes. In all the territory, *Triturus* was consistently found to contain these sphaeriids. The gut of these salamanders was almost empty of any other food, though the animals were picked up from environments rich in larval and adult water insects, plentiful vegetation, and doubtless many micro-organisms. Though superficial examination was made of the lake bottoms, these clams were not plentifully recovered free-living except in one locality, a very shallow swift brook feeding into Norton Mill Creek. Students of the group doubtless know something regarding the feeding habits, but since the literature reports no case of bivalves in the food of *Triturus*, the observation seems worth recording here. The studies to which these records are incident were supported by a grant from the A.A.A.S., through the New Orleans Academy of Science, and from the Highlands Biological Station, to which groups grateful acknowledgement is hereby made.—E. H. BEHRE, *Louisiana State University, Baton Rouge, Louisiana.*

NOTES ON THE OCCURRENCE OF RANID FROGS IN CAVES.—Increasing evidence seems to indicate that the part-time habitation of caves by members of the genus *Rana* is a common occurrence. This is, of course, logical in view of the partly terrestrial habits of many of the species; active migration into caves, many of which have high relative humidities, is thus possible. Rand (1950, COPEIA (4): 324) reported finding *Rana*

pipiens in Indiana caves in winter, and Blair (1951, COPEIA (2): 178) found *R. pipiens* in an Oklahoma cave in November. To these records I should like to add the following observations.

Rana catesbeiana.—A "spring" (the entrance to a small cavern), Nashville, Davidson County, Tennessee; a large adult. The specimen was resting in the entrance, apparently a refugee from its dried-up pond, which is normally fed by the stream from the cavern. When disturbed, it disappeared into a crevice in the rock; this performance was repeated several times during the summer of 1949.

Rana palustris.—(1) Godwin's Cave, Maury County, Tennessee; June 5, 1948; two adults collected in the twilight zone 25 feet from the entrance. The mouth of the cave is 5 feet high and 15 feet wide, and is at the bottom of a sink in a patch of woods in an open field, fully a quarter of a mile from a permanent stream. Relative humidity at this point was 91 percent (sling psychrometer) and the year-round temperature varies only a degree or so from 58° F., the average. The stomachs of the specimens contained beetles, craneflies (Diptera, Tipulidae), and unidentifiable insect fragments. The craneflies were observed to be extremely abundant in the twilight zone during both winter and summer. The cave cricket *Ceuthophilus gracillipes* (Orthoptera, Stenopelmatidae) was also an important element of the parietal fauna in this zone, but was not found in the stomachs, though it should be a good potential food species. On the date the frogs were collected, there was no stream in the cave, but on November 28, 1948, after a light rain had been falling for 24 hours, a small stream was flowing into the mouth; no frogs were observed in November. (2) Yates Cave, Robertson County, Tennessee; June 12, 1950; three adults on a mossy ledge under the overhang of the entrance, above the stream issuing from the mouth. (3) Twin Lakes Cave, Litchfield County, Connecticut; October 10, 1949; one juvenile collected in the twilight zone of the Wet Mouth. The cave entrance is in a small depression in a pine woods 500 yards from a lake.

The observed phototactic response in this species, i.e. negative, with the head pointed toward the light, differs in certain respects from Pearce's laboratory findings with *R. clamitans* and *R. sylvatica* (1910, Proc. Amer. Acad. Arts & Sci., (45): 161-208).

Rana sylvatica.—(1) Mill Creek Cave, Davidson County, Tennessee; August 28, 1948; one juvenile in the twilight zone, 50 feet from the entrance, on a ledge above the cave stream. The year-round temperature averages 59° F., with a deviation of 1° or less; the stream flows in the cave throughout the year, and empties into Mill Creek at the entrance. The entrance is 8 feet high and 25 feet wide, only 30 feet from the Creek. (2) Knox Cave, Albany County,

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New York; February 2, 1950; one juvenile in the total darkness zone, 100 feet below the surface and 200 feet, horizontally, from the entrance, beside a small pool of water. It is difficult to imagine how this frog could have gotten so far underground. The cave entrance is an 80-foot vertical sink in an open field; sub-surface hydrology in the area does not permit a reasonable explanation.

In four out of the six examples given, the frogs presumably entered the caves to avoid summer heat or dryness, and not winter cold, as in Rand's frogs in Indiana, and Blair's in Oklahoma.—THOMAS C. BARR, JR., *Dunster House F-53, Harvard University, Cambridge 38, Massachusetts.*

GROWTH OF ALGAE ON THE TURTLE

EMYS BLANDINGI.—There is apparently some question as to the habitat of Blanding's turtle, *Emys blandingi*, for some specimens have been taken in terrestrial and others in aquatic situations (Carr, 1952, *Handbook of turtles*, Cornell Univ. Press, Ithaca: 132). A specimen that the authors captured on March 30, 1952 at East Harbor State Park, Ottawa Co., Ohio is of interest in this connection as it had a rich growth of algae on its carapace. The specimen was an unusually large male, having a carapace length of 206 mm. This is about the maximum size of Ohio specimens (205 mm.). It was found in a sheltered cove basking on a log a few feet from the shore. At the time of capture, a number of leeches were attached to the base of the legs, and the posterior portion of the carapace was covered with a dense, fresh growth of green algae. The algae extended forward along the mid-dorsal line to the middle of central 4, and along the lateral edge of the shell to marginal 4. Although the alga had dried before identification, it appears to be one of the species of *Basycladia*.

The presence of the algae indicates that this turtle could not have been completely out of the water for any extended length of time during a period of at least several weeks. Possibly the specimen had recently emerged from hibernation, but the distribution of the algae suggests that it had subsequently basked in situations where the back of the body would be immersed in water.

To our knowledge, this is the first report of algae on Blanding's turtle, but algae have been reported on other aquatic species. Since much of the work on the problem of fresh water algae on North American turtles is in botanical journals, and is not well known by zoologists, a résumé is given below. The subject has been reviewed briefly by Hoffmann and Tilden (1930, *Bot. Gazette*, 89: 374), and additional reports have been made by Lagler (1943, *American Midland Nat.*, 29: 257) and Chute (1949, *Rhodora*, 51: 232). The turtles definitely identified are *Chelydra serpentina serpentina*, *Sternotherus odoratus*,

Chrysemys picta marginata, *C. p. belli* and possibly *Graptemys geographica*.

There is some doubt as to the number of algae involved in this association. Collins (1907, *Rhodora*, 9: 198) described one alga as *Chaetomorpha chelonum*. Evermann and Clark (1916, *Proc. Indiana Acad. Sci.*: 477) said of their alga that it "appears to belong to the genus *Microspora*." Hoffmann and Tilden (1930, loc. cit.) refer Collins' *chelonum* to a new genus, *Basycladia*, and also describe a new species, *B. crassa*, from *Chelydra*. They further state, "In all probability the green algae growing on the backs of turtles mentioned by the various writers quoted in this paper belong either to one or to the other of the two species [of *Basycladia*] described." They apparently regard *Microspora* as a misidentification. Later authors have referred their algae to *Basycladia*, except for Allee, Emerson, Park, Park and Schmidt (1949, *Principles of animal ecology*, Saunders, Philadelphia: 243) who cite *Rhizoclonium* as an example of an alga "found only on turtle shells." Allee *et al* give no authority, but may be following Ciferri (1934, *Atti Ist. Bot. Pavia*, 5: 3) in referring *Chaetomorpha chelonum* Collins to *Rhizoclonium*. Ciferri did this for an alga on an unidentified species of *Chrysemys* from the Antilles, but this has not been accepted by algologists, for Smith (1950, *The fresh-water algae of the United States*, McGraw-Hill, New York: 217) retains *Basycladia*.

In respect to *Basycladia*, the relationship is considered to be obligate, but there is doubt as to the benefit, if any, to the turtle. The relationship would therefore be either one of mutualism (symbiosis) or commensalism.

Clearly the subject of algae on North American turtles requires further attention. The distribution of algae on turtles is doubtless more widespread than reported; there is some question as to the number of algae involved, although it is probable that most, if not all, of the algae on North American turtles are *Basycladia* (additional genera have been reported on foreign species); and our knowledge of the value of the relationship to the turtle is at best speculative.—WARREN F. WALKER, JR., AND DONALD M. GREEN, *Department of Zoology*, AND GEORGE T. JONES, *Department of Botany, Oberlin College, Oberlin, Ohio.*

AGGREGATION BEHAVIOR OF THE FEMALE COPPERHEAD, *AGKISTRODON CONTORTRIX* MOKESON, DURING GESTATION.

—Recently I recorded a site where female copperheads congregate during pregnancy (1948, *Herpetologica*, 4: 124-25). This aggregation behavior had been observed every summer for a period of seven years. Similar tendencies to associate have been observed by at least three other authors.

Allen (1868, *Proc. Boston Soc. Nat. Hist.*, 12:

171-204) gave three instances in which females numbering five, seven, and six, were found lying very close together. The first group, found in early July, was not noted to contain embryos, but it seems likely that development was in the very early stages and simply not observed. Of the second group, five that were examined carried "slightly developed embryos." All of the third group were noted to be gravid. H. K. Gloyd (1933, Pap. Michigan Acad. Sci., Arts, Let., 587-604) recorded an aggregation site as follows:

One particular rocky crevice, in which gravid females were collected during three successive seasons, was for some reason especially attractive to the snakes. It was in an open space on the high end of Gould's Ford bluff [near Ottawa, Kansas], under the southeastern edge of a large, immovable fragment of limestone. The cavity was a pocket-like recess extending back about ten or twelve inches, with the opening about two inches high.

Groups of two or three were observed during each of the seasons noted. Another account of this gregarious behavior is given by Minton (1944, American Midl. Nat., 438-77) who found that "copperheads are frequently found in pairs or threes during the summer." In a personal letter on the subject, Minton wrote: "My experience in Indiana confirms your [Connecticut] observations on the aggregation of gravid copperheads during July and August."

Some observations made on September 7, 1946, would seem to indicate that the snakes are responding to an optimum temperature. As reported elsewhere (Finneran, *op. cit.*), nine gravid females were observed on this day in a localized grouping at Coon's Ledge, near Branford, Connecticut. The air temperature at the ledge was 25° C. and a thermometer lying in the leaves of the maternal aggregation registered 28° C. The air temperatures of four other localities visited averaged over 29° C. (31° C., 24° C., 33° C., 30° C.). Lueth (1941, COPEIA (3): 130) reported that snakes undergo a physiological adjustment to the thermal environment when a temperature of 30° C. is reached.

That the females are in an optimum temperature site would also reasonably account for associations of females and their young lasting for several days (Anderson, 1942, Bull. Chicago Acad. Sci., 6: 203-20).—LEO C. FINNERAN, 328 East Liberty St., Ann Arbor, Michigan.

SKITTERING LOCOMOTION IN THE FROG *HYLA CINEREA CINEREA*.—On June 4, 1951, while collecting frogs at a pond near New Bern, North Carolina, I made an interesting observation on *Hyla cinerea cinerea* (Schneider). Many specimens of this frog, when disturbed, leaped along the surface of the water in much the same manner as Blair noted in *Acris crepitans* (1950 COPEIA (3):

237). The pond was about twenty feet wide and fifty feet long. I held many individuals in my hand, and forced them to jump from various heights. They appeared unable to employ the skittering type of locomotion unless the starting point of the leap was well above the surface of the water.—HARVEY S. JANSON, 5747 Pine Street, Philadelphia 43, Pennsylvania.

A SIZE RECORD FOR THE SALAMANDER *BATRACHOSEPS ATTENUATUS ATTENUATUS*.—A slender salamander of unusual size was captured in the Sunset District of San Francisco, California by one of our students on May 13, 1952. The specimen was given to the College for the scientific collections. The salamander was found under a board in a damp location in the rear garden of the student's home.

The coloration is typical of *Batrachoseps a. attenuatus* but the size is far greater than that of any other *Batrachoseps* we have found in this area. In checking through the literature available no record could be found of any specimen of this species that in any way approaches it for size. Storer (1925, A synopsis of the Amphibia of California: 91) gives 130 mm. as the total length of the largest of all of this species in the collections of the Museum of Vertebrate Zoology that he measured. Slevin (1928, The amphibians of western North America: 49) gives 93 mm. as the total length of the largest specimen in the collections of the California Academy of Sciences. Stebbins (1951, Amphibians of western North America: 106) gives 89 mm. as the average length of his specimens and a range of 73 mm. to 114 mm. for those that he measured. This specimen collected in the Sunset District of San Francisco has a total length of 157 mm., or 27 mm. longer than any of the maximum measurements noted above.

The following are the measurements (in mm.) of this giant *Batrachoseps*: total length 157; tail tip to anus 98; snout to anus 59; width of head 6; width of mid-body 8; snout to anterior margin of forelimb 12; interorbital width 1.9; axilla to groin 39.5; length of hind limb 7; length of forelimb 6. There are 20 costal folds. The right forelimb overlaps 3 costal folds when adpressed posteriorly; the right hind limb overlaps 4 costal folds when adpressed anteriorly. There are 13 costal folds between the two limbs when both are adpressed. The tail length is 62 percent of the total length.—EDNA M. FISHER, Science Department, San Francisco State College, 124 Buchanan Street, San Francisco 2, California.

NEW LOCALITY RECORDS FOR TWO OKLAHOMA SALAMANDERS.—The occurrence of *Triturus viridescens louisianensis* and *Siren intermedia*, in northeastern and eastern Oklahoma, re-

spectively, has recently been recorded by A. P. Blair (1951, COPEIA (2): 178). A more recent and more westerly occurrence of these two species in Oklahoma seems worthy of note. In April of 1950, both of these salamanders were collected in the floodplain of the Red River in Bryan County, Oklahoma.

One individual of *Triturus viridescens louisianensis* (Texas Natural History Collection No. 10117) was collected April 7, 1950, in a poorly drained area, 5 miles southwest of Colbert. Additional searching in this area has yielded no more specimens.

On April 2, 1950, a specimen of *Siren intermedia nettingi* (TNHC 9597) was given to me by Mr. C. E. Irwin, a commercial fisherman, who caught it in a small woodland pool, approximately three feet deep and filled with debris and a rank growth of *Myriophyllum*. This pool was located approximately 15 miles southeast of Durant. I visited this locality several days later in an attempt to secure additional specimens but due to the debris and vegetation it was impossible to seine the pool effectively.

These records extend the known ranges of these two species in Oklahoma into the Osage Savanna biotic district.—W. H. McCARLEY, *Department of Zoology, University of Texas, Austin, Texas.*

NOTES ON THREE SUBSPECIES OF THE LIZARD ANOLIS SAGREI IN SOUTHERN FLORIDA.—While collecting in Key West on July 30, 1952, the writer, along with Albert Schwartz, discovered a very large colony of *Anolis sagrei stejnegeri* Barbour. This colony, located in a graveyard in the western portion of Key West, consisted of an estimated two thousand adults and innumerable recently hatched young.

The lizards were very abundant in most parts of the graveyard, but were found in greater concentrations in the more open portions of the area. They were most often observed either on the cement walls and wooden fences surrounding the burial plots or in the grass next to these walls and fences. Unlike *Anolis c. carolinensis*, which was found in close association with it, *A. s. stejnegeri* was frequently observed on the ground, whereas the former was usually seen on trees and shrubs. The recently hatched young seemed to prefer a terrestrial habitat; the adults were more often seen on the walls and fences.

Although *Anolis s. stejnegeri* occurs sporadically in small colonies throughout Key West, this is the only locality known to the writer where the lizards are found in such great abundance.

Nineteen of the specimens are cataloged under No. 106190 in the Museum of Zoology of the University of Michigan.

On December 28, 1951 the writer collected 23 specimens of the common Bahaman lizard, *Anolis sagrei ordinatus*, in the southwestern section of

Miami, Dade County, Florida. This lizard was previously reported by Oliver (1950, COPEIA (1): 56) as introduced in Lake Worth.

On July 23, 1952 the Miami colony was revisited and, in addition to eleven adults, many recently hatched young were seen on the ground adjacent to a coral rock fence. Here *Anolis s. ordinatus* is both arboreal and terrestrial; the great majority of individuals were observed either on the ground or on the lower portions of trees and shrubs. When disturbed, this lizard, in contrast to many members of the genus *Anolis*, often leaps to the ground and takes refuge under rocks or other objects where they are easily captured.

This colony occurs in an area covering about six city blocks in a residential section adjacent to Shenandoah Elementary School. It is this location which offers a possible explanation for their introduction. A teacher at Shenandoah informed the writer that in 1945 or 1946, several of the pupils at that school had purchased lizards from an animal dealer and were keeping them as pets. This colony may be the result of the escape of some of these pets.

Several local herpetologists have said that they had seen specimens of *Anolis sagrei sagrei* from a locality in the northwestern section of Miami, but the writer has been unable to secure any specimens there. However, if the reports are correct, there are two subspecies of *Anolis sagrei* in Miami: *sagrei sagrei* in the northern portion of town and *sagrei ordinatus* in the southern part. If the two subspecies are established it will be very worthwhile to study the effects of intermingling should it occur.

Specimens of *Anolis s. ordinatus* from Miami have been placed in the Museum of Comparative Zoology, Harvard University; the Museum of Zoology, University of Michigan; and in the Reference Collection of the University of Miami.

The writer gives his thanks to Mr. Arthur Lovelidge of the Museum of Comparative Zoology for his courtesy in identifying the specimens of *Anolis s. ordinatus*.—L. NEIL BELL, *Department of Zoology, University of Miami, Coral Gables, Florida.*

THE LINEA MASCULINA, A CHARACTER DIAGNOSTIC OF *HYLA PHAEOCRYPOTA*.—Mittleman (1945, COPEIA (1): 31–37) discussed the status of the bird voiced hyla, *Hyla phaeocrypta* Cope; he showed that it was differentiated in a number of characters from *Hyla versicolor*, and demonstrated that it was identical with *Hyla avivoca*. The examination of four specimens of *phaeocrypta* collected by Dr. H. K. Gloyd, W. T. Stille and myself from a breeding chorus of *H. versicolor* has disclosed an additional character diagnostic of the species. These specimens (RAE 110–113) were collected on the night of 23 April, 1942 from a pond 9 miles east of Fairfield, Wayne County,

Illinois. All four agree closely in all respects with Mittleman's definition of *phaeocrypta*. In addition to the traits listed by Mittleman it was discovered that the lineae masculinae of these specimens were a deep red in color, a red which was clearly evident through the thin skin of the belly of these frogs. *Hyla versicolor* which had been preserved for a comparable period of time were also examined; in this species the lineae is a white or pink and cannot be seen through the skin of the belly. *Hyla versicolor* and *phaeocrypta* are sibling species according to Mayr's definition (1942, Systematics and the Origin of Species: 151; 200-8), and thus have been subject to considerable confusion. A red or pink color of the lineae has been described by Parker (1934, A Monograph of the Frogs of the Family Microhylidae: 15) in species of *Kaloula*, and Liu (1936, Field Mus. Nat. Hist. Zool. Ser., 22(2): 115-56) for a number of Chinese frogs. The latter also notes a number of groups of species which are congeneric, but bear differently colored lineae.—RICHARD A. EDGREN, Division of Biological Research, G. D. Searle and Co., P.O. Box 5110, Chicago 80, Illinois.

ON THE IDENTITY OF THE SNAKE *COLUBER SIMUS* LINNAEUS.—In the 12th edition of *Systema Naturae* (1767) Linnaeus described a snake received from C. D. Garden of Charleston, South Carolina, under the name of *Coluber simus*. It is apparent from the description that a hog-nosed snake was involved. In 1842 Holbrook (North American Herpetology, 4: 57) assigned the trivial name *simus* to Latreille's genus *Heterodon*, and applied the name to the species of hog-nosed snake restricted to the Coastal Plain of southeastern North America. Since that date other authors have accepted this designation without question, although it seems indisputable that Linnaeus had a common hog-nosed snake, and not what Holbrook regarded as *simus*. The counts of ventrals and caudals given by Linnaeus are more typical of the common hog-nosed snake than of the Coastal Plain species. According to the description (*Systema Naturae*, p. 375) these counts were 124 and 46 respectively. Assuming the specimen to have been a member of the Coastal Plain form, these counts are indicative of a male. The number of ventrals is high for this species, and although it is within the range of expected variability (three standard deviation limits), it is slightly beyond the upper limits of the available sample (122 ventrals). In contradistinction to this, these values are well within the range of ventrals of the common hog-nosed snake. The body of the description may be translated as follows:

Head sub-round, snub-nosed, "hunched." Band between the eyes black, curved; top of head with

a white cross, spotted in the center with a black dot. Body above white, varied with black, as if banded with white; venter black.

Much of this description could apply equally well to both species; however, the notation of a white cross on the vertex of the head is typical of the common hog-nosed snake. Similarly the last statement of the description, "venter black," is a common hog-nosed snake characteristic, and would seem to exclude the Coastal Plain form. Although frequent specimens of this latter species show a mottled belly pattern, the mottling is grey-brown; certainly not black. The common hog-nosed snake often shows a generally black belly, the color being best developed posteriorly on adults and uniformly on younger specimens. Linnaeus' type is lost, apparently; Andersson (1899, Bihang Til K. Svenska Vet.-Akad. Handlingar, 24(4; 6): 1) does not list *Coluber simus* in his catalogue of the Linnean types.

On the basis of the above evidence I think it unquestionable that the snake that Linnaeus described under the name of *Coluber simus* was actually the common hog-nosed snake currently known as *Heterodon platyrhinos* Latreille. Strict adherence to the International Code of Zoological Nomenclature would demand that the name *Heterodon platyrhinos* Latreille (1801) be relegated to synonymy and the name *Heterodon simus* (Linnaeus, 1767) be applied to the common hog-nosed snake. This would leave the Coastal Plain species nameless, and require the resurrection of *Heterodon catesbeii* Günther (1858, Cat. Colub. Snakes British Mus.: 83) for it. Günther's name was based upon a composite series of the Coastal Plain species and *Heterodon nasicus* Baird and Girard, but it may be restricted to the form currently known as *simus*; such a restriction would be appropriate as most of Günther's material was of this species (Boulenger, 1894, Cat. Snakes British Mus., 2: 156).

In order to minimize the nomenclatorial confusion which would attend this change of names, I have applied to the International Commission on Zoological Nomenclature to suspend, by use of its plenary powers, the law of priority in the present case, and to confirm the name *Heterodon simus* (Linnaeus) in its present connotation (as *Heterodon simus*, Holbrook, loc. cit.; Stejneger and Barbour, 1943, Checklist, ed. 5: 125) by placing the name *simus* (as published by Linnaeus in 1767 in the combination *Coluber simus*) on the Official List of Specific Trivial Names in Zoology, together with the name *platyrhinos* (as published by Latreille in 1801 in the combination *Heterodon platyrhinos*). This proposal (Edgren, 1952, Bull. Zool. Nomencl., 6: 354-55) has been given the number Z.N.(S.) 662 by Dr. Francis Hemming, secretary to the Commission.—RICHARD

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THE TURTLE *KINOSTERNON CRUENTATUM CRUENTATUM* IN TAMAULIPAS.—One specimen, the carapace measuring about 137 mm. long and 83 mm. wide, was found by Eli R. Burdine near the base of Sierra del Bernal, 5 miles E of Magiscatzin, Tamaulipas, July 8, 1951. This specimen, No. 7305 in Texas Cooperative Wildlife Collection, has three distinct keels on the carapace, an orange-yellow plastron with rounded posterior outline and nearly straight transverse hinges. The axillary and inguinal scutes are present and separated from each other by a lateral projection of the abdominal scute and the anterior movable portion of the plastron is longer than the immovable part.

Although previously reported only from the "isthmus" region of México in Oaxaca, Tabasco, Campeche, and Chiapas, the occurrence of this species in northeastern Mexico is now firmly established on the basis of two specimens: the one mentioned above and one reported by Taylor (1952, Univ. Kansas Sci. Bull., 34 (2): 804) from 3 mi. SSE of Ajinche, near Ebano, San Luis Potosí.—W. B. DAVIS, *Department of Wildlife Management, Agricultural and Mechanical College of Texas, College Station, Texas.*

NORTHERNMOST RECORD OF THE FROG *RHINOPHYRUS DORSALIS* IN MÉXICO.—This large, burrowing, ant-eating toad is relatively rare in collections from localities north of the state of Veracruz in eastern México. Smith and Taylor (1948, Bull. U. S. Nat. Mus., 194: 34) reported it from numerous localities in Veracruz, Oaxaca, Tabasco, Chiapas, Campeche, Yucatan and Quintana Roo, but there is only one record for northeastern México at Hacienda la Clementina, a locality about 50 kilometers north northwest of Magiscatzin. It is therefore of some interest to report the capture of an adult specimen at San Fernando, Tamaulipas, a village less than 100 miles south of Matamoros on the paved highway to Ciudad Victoria. This specimen, No. 6942, Texas Cooperative Wildlife Collection, was picked up by Adolph Dittman in the street in front of the Tex-Mex Cafe in San Fernando on June 24, 1951, a few hours after a torrential rain. According to his report, several of these toads were in the street, but because he was unaware of their rarity in this part of México he saved only one specimen. Seemingly, *Rhinophrynus* responds to rains in the semi-desert parts of its range in a manner similar to that of *Scaphiopus*.—W. B. DAVIS, *Department of Wildlife Management, Agricultural and Mechanical College of Texas, College Station, Texas.*

RANGE EXTENSION OF THE SALAMANDER *BATRACHOSEPS WRIGHTI*.—Wright's salamander, *Batrachoseps* (= *Plethropsis*) *wrighti*, has been known for several years from only two restricted localities, both in Oregon. First collected (in 1936) 8.7 miles southeast of Sandy, Clackamas Co., near the Mt. Hood highway, it was later (1938) discovered at the mouth of Moose Creek on the Middle Santiam River, above Foster, Linn Co.

Recently, a collection was made which extends the range of this salamander approximately 30 miles south of the previous southern limit on the Middle Santiam River. On September 16, 1951, four specimens were collected 1 mile south and $\frac{3}{4}$ of a mile east of McKenzie Bridge, Lane Co., Oregon (T16S, R5E, Sec. 24). Three of the animals were together (within 3 feet) beneath the moss covered bark of a decaying fir log, and the fourth was under a thick bark segment of another. The vegetation here is a rather open second growth fir with relatively little undergrowth. The elevation is between 1600 and 1700 feet.

The present status of two earlier collecting sites (8.7 miles southeast of Sandy and the mouth of Moose Creek above Foster) may be of interest to those who have collected Wright's salamander. On April 29 and 30, 1950, Mr. John Hendrickson, Mr. Donald Dunlap, and the author visited both localities in the course of a three-day field trip. The type locality (determined by road mileage from Sandy) has been and continues to be greatly altered by various construction projects. One of these has involved bulldozing a considerable area and piling the stumps and other debris for burning. Such work was largely adjacent to the highway, so a search was made in a fairly mature stand of conifers with some mixture of deciduous species located south of the road and above the disturbed area. In nearly two hours of work, three *B. wrighti* were located, two well within decaying fir logs, and one beneath the thin bark of a small alder log. Further efforts were made in an area $\frac{1}{2}$ mile east and $\frac{1}{4}$ mile south of Wemme (14 miles by road east of Sandy). This is an old pasture with many small stumps and logs in early stages of decay, plus a few larger, older, and more decayed fir logs. Much of the area is grown to alder brush to a height of about 10 feet. Three Wright's salamanders were found here, all within crevices or termite channels within the smaller logs.

Moose Creek flows into Quartzville Creek which in turn flows into the Middle Santiam River. Moose Creek is 16.5 miles by road from the east end of the bridge over the South Santiam River at Foster. The area about the mouth of Moose Creek was found to have been devastated by a logging operation, resulting in an almost complete removal of the tree

layer and much gouging and scraping of the ground. Suitable habitat for *B. wrighti* no longer exists there. Driving on 1.3 miles, it was found that the area around the mouth of Trout Creek (elevation 1100 feet) has not been recently disturbed, the tree growth being mainly relatively young second growth Douglas fir, with extensive alder thickets in lower areas near the road. In a three-hour search six *B. wrighti* were secured, all being found in moss-covered and decaying fir logs which were quite damp within (water could be squeezed from the rotted wood). The salamanders were found in termite channels, usually well below the surface of the log. *Ensatina eschscholtzi* and *Aneides ferreus* occurred in the same area.—ROBERT M. STORM, Department of Zoology, Oregon State College, Corvallis, Oregon.

PREDATION ON EGGS OF THE WOOD-FROG, *RANA SYLVATICA*, BY LEECHES.—It has previously been noted by P. J. Moore (1912, Geol. Nat. Hist. Surv. Minn., Zool. Ser., 5: 109; and 1923, Roosevelt Wildlife Bull., 2(1): 28) that leeches of the species *Macrobdella decora* are characteristically to be found feeding on the eggs of frogs in the early spring, though no mention was made of the species of amphibian involved.

Confirmation of these reports is afforded by observations made during early April of the years 1949, 1950 and 1951 at Rum Village Woods, a mixed woods, predominantly of beech and maple, southwest of South Bend, Indiana. In each of these years leeches were found in and about egg masses of *Rana sylvatica*.

Detailed observations in 1951 confirmed that the species of leech involved was *Macrobdella decora*. Field notes from April 3 to April 9, 1951 follow: Apr. 3—*R. sylvatica* calling: few in amplexus, but no eggs as yet. Apr. 4—*R. sylvatica* eggs found; some not yet swollen to full size. 14 leeches taken from among them. Apr. 5—More new *R. sylvatica* eggs at periphery of last night's eggs. Many of last night's egg masses appear completely destroyed. 27 more leeches taken. Apr. 6—Practically all *R. sylvatica* egg masses appear tattered. 6 more leeches taken. Apr. 7—6 more leeches taken from the remnants of *R. sylvatica* egg masses. Apr. 8—4 more leeches taken. Apr. 9—No more leeches found.

That there is a considerable degree of specificity in this predation was shown by subsequent observations in the laboratory. When several of the leeches were exposed in an aquarium to eggs of *Ambystoma tigrinum* and *A. maculatum*, as well as to those of *Rana sylvatica*, they were found to attack only the latter. A few worked their way for a short distance into the *A. tigrinum* egg masses, but quickly

left and were not seen to devour any of the eggs. They seemed totally incapable of penetrating the more rigid jelly surrounding the eggs of *A. maculatum*. Needless to say, they were never found about the salamander eggs in the pond, though these occur there at the same time as the eggs of *R. sylvatica*.

In another, smaller pond in the same woods, large numbers of *R. sylvatica* eggs are also deposited. In this pond, however, they have never been seen to harbor any leeches. A possible correlation with this observation is that this smaller pond regularly dries up in late summer, while the larger pond always retains some water.

There can be little doubt that this predation constitutes a serious check on the reproductive rate of *R. sylvatica*, conceivably lowering the population below what the surrounding area could support, and possibly explaining the obviously greater number of individuals breeding in the smaller pond.—BROTHER LAWRENCE CORY, FSC, AND JAMES J. MANION, Department of Biology, University of Notre Dame, South Bend, Indiana.

NOTES ON THE SYRIAN LIZARD *ACANTHODACTYLUS TRISTRAMI ORIENTALIS*.

—The following notes, based on daily observations of *Acanthodactylus tristrami orientalis*, were made near the airdrome, Palmyra, Syria, between February 26 and April 1, 1942. Identifications were made by K. P. Schmidt of the Chicago Natural History Museum, from specimens that I collected in this period and deposited in the United States National Museum.

This lizard was common on hard, stone covered ground in the vicinity of the Palmyra ruins. In Palmyra gardens it was commonly observed between the edge rows of grape vines and on walls surrounding vineyards. When disturbed it sought cover under rocks, in holes, and in crannies in adobe walls.

Native perennial vegetation has been nearly exterminated from desert areas surrounding Palmyra. In the month of March, 1942, annual vegetation occurred only in widely scattered patches a few inches in diameter and was closely cropped by goats.

It was common to flush *A. tristrami* from a distance of 6 to 10 feet. When fleeing it moved ahead in a series of short, nearly straight, dashes varying in length from 3 to 6 feet. These rapid movements are accomplished by combining leg movements with rapid snake-like wiggling.

On February 27, an observation was made on behavior in which normal response to disturbance appeared considerably modified, presumably by the presence of a sudden strong cold wind blowing over the surface of the desert. This lizard, initially dis-

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turbed from a distance of about six feet, scrambled away quickly for 4 yards, then stopped. It remained in the same position for one hour and fifteen minutes. During this period a wind-blown paper passed within six inches of the head of the lizard; and a continuous trail of small ants and a solitary fly moved past within 12 and 2 inches, respectively, of its head. During the last half hour, I was standing within one foot of the animal which was, finally, easily collected (U. S. Nat. Mus. No. 123732). When motionless this lizard blended well with its background. Its outline was difficult for me to distinguish from as close as 4 feet.

On February 27, on the level desert near Palmyra airport, I attempted to learn the boundaries of the immediate home range of one lizard. When first seen, this lizard headed straight for its burrow entrance, which was partially blocked by a small flint rock. For the next three minutes I tried to force it as far from its burrow as I could. Within a radius of $3\frac{1}{2}$ to 4 yards the animal appeared to be thoroughly acquainted with the area, and its movements were quick and unhesitating. Once it reached the periphery of an approximate 4-yard radius from the burrow, it would become uncertain of movement and would stop and change direction. It was clearly disturbed by me and made every effort to avoid approach. Finally, it made another dash at the entrance hole and, after a little over 2 seconds prying, forced its body past the small rock obstruction and vanished into its burrow (Fig. 1). This lizard, then, was familiar with a small nearly circular area of desert ground about 8 yards in diameter. The ground was level and appeared typical for this part of the desert. On it were small flint rocks up to three inches in diameter; the average diameter of 50

stones measured was one inch. Present also within the area were two ant holes and three sparse patches of grass, each 2 to 3 inches on a side and roughly square.

A lizard burrow was excavated on a level stretch of stony ground near Ouermere, Palmyra. The

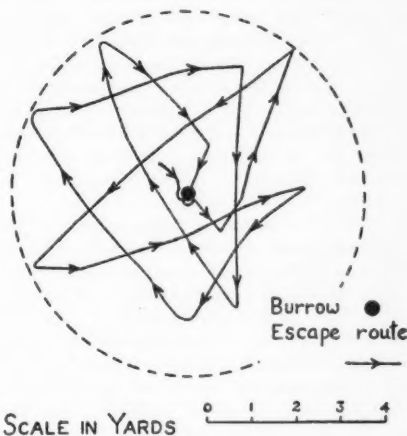


Fig. 1. Route taken by *Acanthodactylus tristrami* when attempts were made to force it away from its burrow

entrance diameter was one-half inch. The passage led down at a 30-degree incline for 3 inches, levelled off, then turned nearly 90 degrees and continued for 6 inches to the end of the burrow. There the lizard was found lying in the slightly enlarged terminus and was facing the entrance.—THANE RINEY, Museum of Vertebrate Zoology, Berkeley 4, California.

REVIEWS AND COMMENTS

THE BRITISH AMPHIBIANS AND REPTILES. By Malcolm Smith. Collins, London, 1951: xiv + 385, illus. \$3.00.—The author of this finely illustrated addition to the distinguished NEW NATURALIST series is so well known for his contributions to the herpetology of Asia, among them his *Mono-graph of the Sea Snakes*, a veritable model among taxonomic studies, that it may come as something of a surprise to his American colleagues to find him so much interested in the habits and general natural history of the salamanders and frogs and toads and

lizards and snakes of Great Britain. When I had the pleasure of visiting him at his country-house in Surrey in 1950, he was engaged in watching lizards in outdoor cages and newts in indoor terraria, and was full of enthusiasm for the study of the habits and behavior of amphibians and reptiles as the natural sequel to the acquisition of a knowledge of their names and classification. With this enthusiasm and with the doctrine that a sound knowledge of morphology and classification should serve as the foundation for studies in physiology and behavior,

I am fully in accord. The modern taxonomist is inevitably led by his studies of distribution into becoming a geographer and an ecologist, for our animals and plants exist in much more intimate relation to the web of surrounding plants and animals and to their inanimate environment, than to their *species*. It is true that the species must be known first; but once known, the next step is the study of the community in which its individuals live and move. In this study, the examination of the relations between structure and behavior is still relatively an unexplored field, one that leads the laboratory student into the field and the outdoor naturalist into the laboratory. Dr. Smith's book serves as an elementary text for this aspect of herpetology.

Meanwhile, fine justice has been done to the taxonomic aspect of the herpetological fauna of Dr. Smith's native land, and his publishers have provided eighteen colored plates from color photographs by W. S. Pitt. The black and white illustration is scarcely less distinguished. No one should miss the photograph of the common European toad in its ridiculous and comical defense posture. A notable chapter on the viper in Britain includes an account of the fighting between male vipers, which is interestingly paralleled by the combats between male rattlesnakes; these performances were long misunderstood and interpreted as courtship posturing between the sexes.

The chapter headings will serve to give a further idea of the content of the book. They are: 1, Herpetology and its early history; 2, Geographical distribution and the origin of the British amphibians and reptiles; 3, The newts; 4, The toads and frogs; 5, The lizards; 6, The snakes; 7, The marine turtles; 8, Parasites; and 9, Some unsolved problems in herpetology. These headings, however, give no clue to the real importance of this work, which far transcends its stated function as an up-to-date guide to the amphibians and reptiles of Britain. This importance might be deduced from the headings of the first and last chapters; the book in fact serves as an admirable introduction to the whole scope of herpetology. It is therefore to be highly recommended to that large class of American young people who have a mysterious drive to study reptiles and a consuming ambition to become herpetologists.—KARL P. SCHMIDT, *Chicago Natural History Museum, Chicago 5, Illinois*.

THE STUDY OF INSTINCT. By N. Tinbergen. Oxford University Press, London, 1951: xii + 228, 130 figs. \$7.00.—In the early 1930's Konrad Lorenz, ornithologist and student of animal behavior initiated a series of studies utilizing a special approach and new terminology to the study of animal behavior. Almost from the inception of this

program Dr. N. Tinbergen has been Lorenz's most illustrious collaborator. In 1947 Dr. Tinbergen was invited to present a series of lectures under the auspices of The American Museum of Natural History and Columbia University, and the present volume is an extension of these talks. Most of the early studies of the Lorenz-Tinbergen school are written in German and this book represents the first concise summary in the English language of the efforts of these investigators and their followers. Since a special approach to the study of animal behavior is involved, they choose to call their science by the special name "ethology" and as the author explains, the book is an attempt at an organization of ethological problems into a coherent whole.

The Lorenz-Tinbergen school concerns itself primarily with innately organized behavior. Conditioning, learning and higher mental processes are viewed as secondary and disparate modifications of innate mechanisms and hence are treated briefly and only in relation to the central problem. Emphasis is placed avowedly on a strictly objective approach, in which a major goal is the determination of causal relationships underlying the observed phenomena.

Behavior is considered a reaction to external stimuli and internal causal factors. However an animal does not react to all factors in the environment which its sense organs are capable of receiving, but only to a small part of them. These essential stimuli are called "sign stimuli." In general, animals react to only a few sign stimuli at any one time and there is a strict dependence of an innate reaction on a specific set of sign stimuli. This leads to the conclusion that there must be a special neurosensory mechanism that releases the reaction. This mechanism is called the "innate releasing mechanism." Accordingly each innate behavioral act has its own innately organized central nervous mechanism, described here as a series of centers arranged in a hierarchical manner. Higher centers are rigidly connected with lower centers but discharge to the lower centers is normally blocked, a condition which prevents continuous discharge. The innate releasing mechanism when activated by the proper sign stimuli removes the block which then permits activation of the next lower centers and at the same time may cause the appearance of one portion of the instinctive act. Hence the individual reactions which comprise the instinct are also arranged in a hierarchical manner.

Many ramifications follow from this basic concept, e.g. heterogeneous summation, vacuum reactions, displacement reactions, social releasers, chain reactions, etc. In addition, an extensive attempt is made to correlate both data and theory with the findings of the neurophysiologists, particularly in regard to locomotion. In the last chapters various

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aspects of the development and evolution of behavior are considered, and the book ends with a brief consideration of instinctive behavior in man.

Ichthyologists and herpetologists are often confronted with behavioral problems, and not being specialists in behavior they may accept the major premises of this book without serious question, especially since the material is presented in a very convincing and engaging manner. In all fairness to such readers it should be stated that while the Lorenz-Tinbergen school of thought has been known to American psychologists and students of animal behavior for many years, it has met with only a very limited acceptance. It has made its greatest appeal among certain ornithologists, probably because the mechanistic approach forms an easy frame of reference for the description of bird behavior. Many fundamental difficulties arise when the system is appraised as behavior theory. In the eyes of this reviewer the most serious criticism is the strict and unnatural dichotomy between innate and learned behavior. The major criterion for the determination of innateness is whether or not such behavior appears when the animal is raised in isolation,—presumably, but never clearly stated, visually and tactually isolated from members of the same and closely related species. It would appear that the author does not consider the human caretaker of the isolated animals, or the presence of parasites and cage pests, or the inanimate surroundings of the isolate, as realia of the environment with which the animal can interact. Nor is the possibility considered, as has been suggested recently, that an animal's behavior may be fundamentally influenced by experiences with its own body. Although his real assumptions are stated rather vaguely, Dr. Tinbergen seems to believe that the basic instinctive patterns in animals and man are solely the product of an inheritance which causes the nervous system to develop into a rigid series of centers and mechanisms capable of producing well integrated preformed behavior patterns. This, it may be recognized, is contrary to the view of modern geneticists who do not eliminate environmental influences from their considerations. They may often attempt to keep external factors constant for a given experiment, but they are fully aware that changed surroundings may yield a changed phenotype. Recent studies of morphogenesis all stress the constant interaction of gene, organism and environment in the development of structure. There is really no defensible reason to assume that in behavioral development special processes occur which are independent of the *milieu* or of experiences and actions of the animal. Moreover it should be noted that experiences and actions of an animal are in reality just parts of a changing environment. Completely ignored by the author are studies which demon-

strate the inextricable and basic relationship of environment and experience to behavior patterns commonly referred to as instinctive.

The basic problem as formulated by Dr. Tinbergen seems to be as follows: *Instincts are innate processes. We should endeavor to learn how they function.* A better formulation would be: *Some behavior is species constant. Developmental and physiological studies should reveal why this is so.* In this way unwarranted assumptions concerning innateness are avoided.

Most of the further difficulties stem from this fundamental objection. A rigid conception of nervous centers like that adopted in this book may fit in very well with a nervous system preformed in the genes, but it is not in keeping with modern concepts of neurology. For example Dr. Tinbergen oversimplifies the work of Hess and claims that he demonstrated centers in the hypothalamus which control the complete patterns of fighting, eating and sleeping. But the validity of such statements cannot be appraised without considering also the extensive evidence of American neurologists who find that complete centers of organization are not demonstrable.

Having formulated a system of releasers and releasing mechanisms the author now proceeds to apply the system without due regard to phylogenetic considerations or to extensive morphological and physiological differences. Using similarity of behavior as the major criterion, generalizations are derived which apply equally, for example, to echinoderms, arthropods, fishes, amphibia, birds and mammals. This type of generalization cannot be accepted without a far more thorough analysis of the observed phenomena than the author has made. The extreme to which this approach naturally leads is well illustrated in the final pages of the book where one finds the doubtful statement that the profile of the head of the human infant plus its maladjusted limb movements are the sign stimuli which release the parental instinct. This will surely not appeal to the average psychologist.

Despite the many and fundamental criticisms, this is an important book and one that should be read by all students of animal behavior. It should be of particular interest to ichthyologists, since many of the examples cited are taken from studies on fish behavior. The ingenious experiments and theoretical discussions will afford many hours of stimulating reading.—LESTER R. ARONSON, *Department of Animal Behavior, The American Museum of Natural History, New York.*

FRESHWATER FISHERY BIOLOGY. By Karl F. Lagler. First Edition. Wm. C. Brown Co., Dubuque, Iowa, 1952: x + 360, 184 figs. \$5.75.—This, the first text on the subject in North America,

was written chiefly to provide a documented reference for students, teachers and professional workers. Its usefulness is greatly enhanced by the concise yet sufficiently detailed treatment, the numerous, informative and clear-cut illustrations, and the handy list of references at the end of each chapter which will serve to stimulate the serious student in his quest for further knowledge.

There are 25 chapters and 5 appendices. The first 15 chapters deal with the natural history and ecology of fishes, classification, literature, anatomy and embryology, early life history stages, food habits, age and growth, population studies, yield analysis, diseases, and pollution. This is followed by two chapters on fishing laws and fish culture, with Chapters 20 and 22 dealing with lake and stream improvement. The methods used in carrying out fishery surveys (mapping, chemical and physical analyses, biology) are treated in Chapters 18, 19 and 21. The last 3 chapters are concerned with the creation of new fishing waters, commercial fisheries, and recreational fisheries. The appendices present a photographic survey of the scales of common families of North American freshwater fishes, blank data forms used on fishery surveys, abbreviations for words appearing in technical journals and periodicals, clinical aspects of certain fish diseases, and conversion tables. All of these data add much to the usefulness of the book, which closes with an adequate index.

Much of the volume is devoted to a description of the routine methods by which the biological basis for management is secured by fishery workers. The several methods used in the various aspects of this field are presented and adequately criticized, and the study programs, which appear at the end of nearly every chapter, are well planned. The reference lists for each chapter are up to date and complete.

Certain small details are objected to by this reviewer. One is the use of the terms "poisoning" and "poisons" (p. 10) for the action of materials with rotenone as the active ingredient. These terms, al-

though widely established, are a poor choice for use by fishery workers who are constantly faced with public relations work; I favor using rotenone as a verb. Guide lines (vertical rules) are needed for more ready interpretation of the tabular material on pages 21-36 and 96. Cresol has been used in the southern Appalachian Mountains as a successful method for studying trout populations (p. 135). The disadvantages of simplified diagrams are encountered in Figure 93 (p. 220) which shows a thermally stratified lake that lacks fish in the region of the hypolimnion. This portion of northern lakes, in particular those in and near the Great Lakes region, is critical to the summer survival of such important fishes as whitefishes, ciscoes, and the lake trout. These and other minor (typographical) errors can readily be taken care of in a revised edition.

The binding and format are excellent, the type is particularly readable, and the photographs are generally very clear. Both Dr. Lagler and the publisher are to be congratulated for producing such a fine book. It will be of interest and value to fishery workers everywhere.—ROBERT RUSH MILLER, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

PROCEEDINGS OF THE FIRST PAN-AFRICAN CONGRESS ON PREHISTORY. Edited by L. S. B. Leakey. Philosophical Library, N. Y., 1952, 239 pp., illus. \$8.75.—This is a series of 53 essays on the geology, general and human paleontology, climatology and prehistorical archeology of Africa by leading students of the prehistory of that continent. Unfortunately printing costs necessitated a drastic shortening of the original papers, presented at the Congress in 1947. Papers on Pleistocene climatic changes (by E. Nilsson), Past climates (by E. J. Wayland), Mediterranean and Tropical Pluvials (by F. E. Zeuner), Pleistocene Lakes in Tanganyika (by D. R. Grantham), and Faunistic Evidence of Former Hydrographic Connections (by E. B. Worthington) will be of particular interest to students of the zoogeography of Africa.

EDITORIAL NOTES AND NEWS

Southeastern society

The second annual meeting of the Southeastern Society of Ichthyology and Herpetology

(formerly the Southeastern Herpetological Society) was held on October 24-25, 1952 at the University of Alabama in Tuscaloosa. Thirty-five people repre-

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sending fourteen institutions attended the sessions. Following is a summary of the two-day meeting:

Friday, October 24

- 8:30-9:00 AM Registration
- 9:00-12:00 AM Presentation of papers
- 2:00-4:30 PM Institutional reports of available facilities and research in progress
- 6:00-8:00 PM Barbecue, Moundville State Monument
- 8:00-11:00 PM Examination of University of Alabama collections

Saturday, October 25

- 9:00-10:00 AM Business meeting
- 10:00-12:00 AM Presentation of papers
- 2:00-6:00 PM Field trips and examination of collections

Plans were made to present to the American Society of Ichthyologists and Herpetologists a formal request that this regional organization be recognized as a Southeastern Division of the national society. The boundaries of this Southeastern Society include the States of Virginia, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, Tennessee, Kentucky and the District of Columbia. Officers elected for the coming year were: President, RALPH W. YERGER, Florida State University; Vice-President, DONALD C. SCOTT, University of Georgia; Secretary-Treasurer, WILFRED T. NEILL, Reptile Institute (Silver Springs, Fla.).

The third annual meeting is scheduled for the fall of 1953 at the University of Georgia in Athens. A symposium on the "Factors affecting distribution of poikilothermic vertebrates in the southeastern states" is being planned for this occasion.

News notes Scripps Institution of Oceanography is developing its exploration of the pelagic and deep-sea fish faunas of the Pacific.

The research ship *HORIZON* has returned from the Shellback Expedition to Peru and the equatorial current system of the eastern Pacific, with a wealth of new material, though such collecting was a minor phase of the program. The *HORIZON*, and the SPENCER F. BAIRD, the newest addition to the Scripps high-seas fleet, are now undertaking oceanographic research in the Central Pacific. Collections will be made at the surface, in mid-depths, and on the bottom, including the very great depths attainable with the new tapered cable and special winch installed on the BAIRD. Considerations are being given to a primarily biological cruise to the Philippines in the fall of 1953.

In 1949, the University of Wisconsin and the Wisconsin Conservation Department instituted a long-term study of the effect of selective breeding

to improve the quality of trout raised in state hatcheries. Selection of trout is being made to obtain a rapid rate of growth, disease resistance, and an increased production of eggs. The work is to be done at the James Nevin Fish Hatchery at Madison, under the supervision of DR. A. D. HASLER and DR. J. F. CROW of the Department of Zoology, University of Wisconsin, and E. HERMAN and W. C. THREINEN of the Conservation Department, with help from graduate assistants in the University. The assistantships pay \$1380 per annum, with free out-of-state tuition. Applicants should have some experience in fisheries work and some knowledge of genetics and biometry.

MR. IAN S. R. MUNRO, Australian fisheries biologist, of the C.S.I.R.O. Fisheries Laboratory at Cronulla, New South Wales, spent the period from April to December, 1952, visiting fish and fishery centers in various parts of the world. His trip was sponsored by the Australian Commonwealth.

SVEN SPØMME, government inspector of salmon and freshwater fisheries for Norway, resigned on August 1, 1952, and is continuing private work as a fisheries biologist with address at Prinsensgt. 2c^{IV}, Oslo, Norway.

DR. EDWIN L. COOPER has resigned from his position of Associate Fisheries Biologist with the Michigan Institute for Fisheries Research, effective November 18, 1952, to become Chief Aquatic Biologist in the Wisconsin Conservation Department, 830 State Office Building, Madison, Wisconsin.

A fast-moving drama was set into motion when LEE HOUSTON, Nebraska snake handler, was bitten by a "diamondback rattler" while complying with the order of Cuban customs officials to destroy all poisonous snakes in his collection of live reptiles designed for exhibition in that island republic. Although there are no poisonous snakes in Cuba, two vials of Antivenin, sent there through error, were discovered. On hearing about the critical situation, the American Embassy called Miami where two more vials were located and were flown to Havana by a Navy plane. Next, Wyeth Incorporated of Philadelphia, the only manufacturer of Antivenin in North America, received a request for additional serum. A search was instigated by long-distance telephone and seven more vials were found in Miami and vicinity. These were then flown to the Hospital Anglo-Americano in Havana by Pan American Airways. The total elapsed time from the moment of the bite until the hospital received the last seven vials was twelve hours. HOUSTON recovered.

In order to reduce its stock of back numbers of the *Annals and Memoirs* to a desirable minimum number of copies of each volume and in order to make certain classic publications (Vol. 5 of the

Memoirs, for example, is Eigenmann's "The freshwater Fishes of British Guiana") more readily available, Carnegie Museum announces drastic price reductions which will prevail until the designated excess—20 to 200 copies—has been sold. Orders should be addressed to Assistant Director, Carnegie Museum, Pittsburgh 13, Pa. Volumes 2 through 8, bound, of the Memoirs, formerly priced at \$10.00 to \$12.00 each, are being offered at \$4.00 each, postage to any point in the continental United States included. Volumes 1 through 14 of the Annals, formerly priced at \$4.00 each, are available at \$1.50 each, postage included. In many instances paper bound parts of Volumes 1 through 12 of the Annals can be supplied at \$1.00 each to those who do not wish to purchase the entire bound volume. Reprints of individual papers, except in rare instances, are not available in large enough quantity to permit price adjustments, but inquiries about specific papers are invited.

GEORGE B. RABB, Museum of Zoology, University of Michigan, is collecting reptiles and amphibians in the Bahama Islands as a member of the Van Voast-American Museum of Natural History Expedition which set sail from Miami on December 29, 1952.

Corrections In COPEIA, 1952 (3), p. 213, lines 10 and 11 down from top, A. FRASER-BRUNNER (not Vesey-Fitzgerald) should have been credited as the illustrator of *Game Fish of the World*, edited by Vesey-Fitzgerald and La-Monte. The reviewer, as well as the editors, regrets this error.

In the same issue, page 220, student award winner RICHARD E. NOBLE should have been listed as a member of the Department of Fish and Game Management (not the Zoology Department) of Oregon State College.

The premature thanks given to THOMAS OELRICH for financial aid (1952, COPEIA (4): 290) come of age with the publication of the present issue.

New York Meetings

The Henry Hudson Hotel will be the official headquarters for the National Meeting of the Society in New York, April 22-26, 1953. The Board of Governors will meet at 8 PM on April 22. Registration will take place at the American Museum of Natural History on Thursday, April 23, and that day and Friday the 24th will be devoted to the presentation of papers at the Museum. There will be a Smoker at the Museum the night of April 23 and the Annual Banquet will take place the evening of April 24 at the Henry Hudson Hotel. Saturday, April 25, will be taken up with the presentation of papers at the Bronx Zoo and a luncheon at the New York Zoological

Society. On April 26, an excursion to the Barrett Park Zoo on Staten Island is scheduled.

Copeia mailing dates, 1952

Copeia, for 1952, was mailed at the post office in Baltimore, Maryland, on the following dates: No. 1 on June 28, No. 2 on August 1, No. 3 on October 6, and No. 4 on January 27, 1953.

The second Coelacanth

THE second known living coelacanth fish, *Malania anjouanae* Smith, was caught by a native fisherman on a fish-baited line on December 20, 1952, in about 8 fathoms over a rocky bottom only 200 meters offshore from Domoni, Anjouan Island, in the Comoros Archipelago west of the northern tip of Madagascar. It was saved from being cut up for market by another native who recognized its value from a leaflet about *Latimeria*. Thousands of these leaflets (in Portuguese, French and English), giving a picture of *Latimeria*, had been distributed throughout the coastal areas of the western Indian Ocean, offering a reward of £100 (\$282) for the first two specimens caught.

The fish, a male nearly 4 feet 8 inches in total length, was killed by blows on the head and, in the absence of formalin, was initially preserved by slicing along the back from snout to tail for salting; this destroyed the brain and other soft parts of the head. *Malania* almost certainly falls in the family Latimeriidae, but differs from *Latimeria* in the absence of a first dorsal and of a supplementary caudal fin, and also in a number of lesser meristic characters. There are no internal nares, but rather three external openings (as in *Latimeria*) which communicate directly with the median rostral cavity only; there is also a well developed spiral valve. The brain case is almost exactly like that of *Latimeria*. There are pseudobranchiae and five gill arches; the intestinal canal is short, with only two flexures. The scales resemble those of *Latimeria*. Although absent, the first dorsal is represented by a typical basal plate. The original description, by Dr. J. L. B. SMITH, appeared in Nature for January 17, 1953.

The natives of the Comoros know the Coelacanth well and name them "Gombesa"; they assert that one or two a year have been caught off Anjouan Island. The scales are stated to be used to roughen bicycle tubes when mending punctures. There is a report of a similar, but smaller, fish which may prove to be another species, and they are considered as formidable as any rock cod (Serranidae).

There is every hope that further specimens, including perfect ones, may be secured and it is not even impossible that they may be found in similar habitats in other oceans.—Information in letter from J. L. B. SMITH.

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